VOLUME 28 NUMBER 6

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NEXT MONTHLY MEETING, FEBRUARY 12, 1907

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PROCEEDINGS

FEBRUARY, 1907

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INDIANAPOLIS MEETING, MAY 28-31, 1907

FEBRUARY, 1907 VOL. 28. No. 6

THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS

PROCEEDINGS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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The professional papers contained in Proceedings are published prior to the meetings at which they are to be presented, in order to afford members an opportunity to prepare any discussion which they may wish to present. They are issued to the members in confidence, and with the understanding that they are not to be published even in abstract, until after they have been presented at a meeting. All papers are subject to revision.

The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.

Proceedings is published twelve times a year, monthly except in July and August, semi-monthly in October and November.

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PROCEEDINGS

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 28 FEBRUARY, 1907 NUMBER 6

THE dedication of the building of the Engineering Societies will take place on April 16 and 17. It is probable that there will follow a professional session of the Engineering Societies at this time.

As a separate session, or as a joint meeting, The American Society of Mechanical Engineers will be addressed by Brigadier-General Arthur Murray, Chief of Artillery, U. S. A., and Brigadier-General William Crozier, Chief of Ordnance, designer of the type of disappearing gun now used in coast defense. These addresses will deal with the general subjects of fortifications and coast defense, and will be of great interest to all members.

THE NEW HOME OF THE SOCIETY

On the first of January, the Society moved its offices into the building of the Engineering Societies, 29 West 39th Street.

The library and house at 12 West 31st Street, however, will be open until about March 1, after which time the library will be moved to the twelfth and thirteenth floors of the Engineering Building, where spacious and light rooms, equipped with the most approved designs of library furniture are provided for the combined libraries of the Engineering Societies.

The Thirty-first Street house will not be open after the above mentioned date. To those who belong to the Engineers Club this will not be an inconvenience, and we trust that the benefits of the new home of engineering will more than compensate the other out-of-town members who have stopped at the Society House.

REGULAR MEETINGS

The attention of the members is called to the regular meetings, which take place on the second Tuesday of each month. The Society hopes for a large attendance at these meetings, and an endeavor is being made to provide addresses which will be of marked interest.

SPECIAL NOTICES

The Society hopes not to be obliged to issue special notices for meetings. They will be announced in Proceedings in advance of the meeting at least in one or two numbers, and it is expected that the members will at least read Society Affairs in regard to the Society's activities.

We wish to discontinue the practice of sending out special notices of all kinds, and the columns of Proceedings will be used for announcements of interest to the membership. This will relieve the office staff of much extra work and the Society of unnecessary expense in addressing, individually, circulars and letters to members when the same notice can be given as effectively through Proceedings if the members will do their part and read the announcements under Society Affairs.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS AT SOUTH BETHLEHEM

Prof. Joseph F. Klein, occupying the chair of Mechanical Engineering at Lehigh University, has just been presented by the Alumni and student body of Mechanical Engineering, with a life membership in this Society, as a testimonial, in recognition of the completion of twenty-five years of service.

The Secretary was present at the University, on Tuesday evening, January 22, when the presentation was made. A full account of this interesting occasion will be given in the next number of the Proceedings.

THE FEBRUARY MEETING

Tuesday evening, February 12

Mr. C. E. Sargent, of Chicago, will read a paper on "The Testing of Inflammable Gases." This paper was published in the December Proceedings.

Prof. Charles M. Allen, of Worcester Polytechnic Institute, will deliver a lecture on "Gasolene." The lecture will be illustrated by

experiments showing the chemical combinations necessary to produce an explosive gas and the combination of air and gas for producing an inflammable liquid. Members are especially urged to invite all persons engaged in the automobile industry. The Alumni of Worcester Polytechnic Institute are also cordially invited to be present.

MARCH MEETING

Tuesday Evening, March 12

Mr. John W. Lieb, Jr., Vice-President of the Society, will deliver an address on "Vesuvius and Pompeii." It will be profusely illustrated by slides specially imported for this lecture, and pictures representing Vesuvius in eruption. The illustrations were procured by Mr. Lieb at great trouble and expense, and we expect a very interesting evening for the members and friends of the Society who are present.

DISCUSSION

Discussions on papers presented at the Annual New York Meeting will be received until February 8, which will allow time for publication in March Proceedings. We do not expect to include discussions in the April number, as this issue has been reserved for the authors' closures and papers for the Indianapolis Meeting.

FOREIGN POSTAGE

Our foreign members have called attention to the fact that catalogues, price lists, and other communications from American firms are frequently understamped. Members who use the Year Book and Pocket List as mailing lists, will, we know, be pleased to instruct those who have charge of the work to see that foreign mail is fully prepaid. Wherever this is not done the Post Office exacts as a penalty an excess amount of double rate. Post Office officials are rigorous in their interpretation of the international postal regulation, and unfortunately the innocent is made to suffer for the guilty.

BIBLIOGRAPHY

A bibliography of papers published either by the Society or others bearing on Mr. Taylor's system of management has been prepared. The Society can supply any or all of these publications. The

Secretary would be glad to be advised as to any additions which should be made to this list.[1]

COMMITTEES FOR THE INDIANAPOLIS MEETING

The following is the personnel of the Chairmen of the Committees for the Spring Meeting at Indianapolis, May 28th to 31st. General Chairman of the Local Committee, Mr. J. R. Wittemore. The Finance Committee, Mr. L. M. Wainwright. The Ladies' Committee, Mr. W. E. Sharp. The Entertainment Committee, Mr. H. H. Rice. The Hotel Committee, Mr. W. G. Wall. The Printing and Press Committee, Mr. Theo. Weinshank.

The Committees are making a great effort to make the meeting especially attractive. The Meetings Committee, on their part, promise professional sessions of extraordinary interest.

PROGRAM OF MEETINGS OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

One of the great advantages of the Engineering Societies is the opportunity of a member of one society to attend the meetings of all the societies. The members of the A. S. M. E. are cordially invited without further notice to attend the following, to be held in the Engineering Societies Building:

February Meeting, March 1, 1907.

"Alternating Current Electrolysis," by J. LeR. Hayden.

"Electrolytic Corrosion of Iron and Steel in Concrete," by A. A. Knudson.

[1] The Machine Shop Problem, by Charles Day. Paper 1001, Transactions, v. 24, p. 1302. 10c.
Slide Rules for the Machine Shop, by Carl G. Barth. Paper 1010, Transactions, v. 25, p. 49. 5c.
A Bonus System of Rewarding Labor, by H. L. Gantt. Paper No. 928, Transactions, v. 23, p. 341. 10c.
A Graphical Daily Balance in Manufacture, by H. L. Gantt. Paper No. 1002, Transactions, v. 24, p. 1322. 10c.
Modifying Systems of Management, by H. L. Gannt. Paper No. 1011, Transactions, v. 25, p. 63. 5c.
A Piece Rate System, by Fred W. Taylor. Paper No. 647, Transactions, v. 16, p. 836. 10c.
Shop Management, by Fred W. Taylor. Paper No. 1003, Transactions, v. 24, p. 1237. 45c.
The Art of Cutting Metals, by Fred W. Taylor, Proceedings, v. 28, No. 3. $1.25.
Discussions Art of Cutting Metals, Contributed, Proceedings, v. 28, No. 4, 5, and 6, each 50c.
The Value of Non-Producer in Manufacturing Plants, by H. K. Hathaway, "Machinery" November, 1906. 20c.
History of the Introduction of a System of Shop Management, by James M. Dodge, Proceedings, v. 27, p. 720. 5c.
Sketch of F. W. Taylor, "Cassier's Magazine." December, 1905. 25c.

March Meeting, March 29, 1907

"Lighting and Lighting Protection," by C. P. Steinmets, E. E. F. Creighton and D. B. Rushmore.

April Meeting, April 26, 1907

"Rowland Telegraphic System and its Apparatus," by Frank M. Potts.

May Meeting, May 24, 1907

"Turbo-Alternators, by B. A. Behrend.

"Zigzag Leakage of Induction Motors," by R. E. Helmund.

Annual Convention (location not yet fixed)

"Some Power Transmission Economics," by F. G. Baum.

"Notes on Transformer Testing," by H. W. Tobey.

"Single Phase, High Tension Power Transmission," by E. J. Young.

"Ten years of Niagara Power," by H. B. Alverson.

"Fractional Pitch Windings for Induction Motors and Alternators," by C. A. Adams.

"Attitude of Technical Schools Toward the Profession of Electrical Engineering," by H. H. Norris and Professor Karapetoff.

"Engineering Specifications," by C. W. Ricker.

"Vector Diagrams of Single Phase Commutating Motor," by W. I. Slichter.

THE JANUARY MEETING

Tuesday Evening, January 8

The first monthly meeting of the Society was held in the large auditorium of the Engineering Societies on Tuesday evening, January 8, and was addressed by Frederick P. Fish, Esq. The subject was "The Ethics of Trade Secrets." The address, which is published in this number, is a valuable one and of particular interest to engineers. The meeting was attended by nearly one thousand people. It was gratifying to the Engineering Societies to find that the acoustic properties of the auditorium were excellent, in fact many consider it the best in New York.

President Hutton made the following introductory address:

"It is the wish of The American Society of Mechanical Engineers, under whose auspices we are holding this meeting tonight, that we should regard it distinctly as an informal gathering, and not in any sense as the official opening of the Engineering Societies Building. For reasons of weight connected with our desire to have the founder

and donor of the building present at the time that such official opening shall take place, it will not be held until the month of April. On the other hand, it has seemed very undesirable to hold the building closed and unavailable for its uses until after that formal opening. The Societies, therefore, who are the beneficiaries under Mr. Carnegie's deed of gift and the other Societies who are the associates with us in the management and benefits of the building, will begin at once to hold their meetings in the auditoriums of the building. The Society of Mechanical Engineers happens, by a lucky coincidence, to be the first of the bodies to hold its meetings in this room.

The Institute of Electrical Engineers will hold its meeting by appointment on Friday, the 25th of January, 1907, and the Railroad Club and other organizations will begin on their stated meetings during the month of January and thereafter. The Society of Mechanical Engineers has reserved for itself the second Tuesday of each month.

I think, however, that I should be sluggish and inert if I did not on your behalf give voice to the thrill and tingle of my own nerves that it should be given to our Society to be called to order the first in the succession and that it should be given to me to do it for the first reunion in this building.

It is a matter which is singularly noteworthy that in the history of engineering in this country, and in the history of Anglo-Saxon civilization, and, therefore, in the history of the world, that a gathering like this should be held now for the first time, in a building devoted to the interests of engineering in its divers specialization, and under the roof of such a building intended to emphasize at once the diversity of these specialties and yet withal their fundamental unity. Nowhere else is there a building like this, in which the different branches of engineering are met together as one, and where their unity is to be emphasized by their meeting for conferences, by the existence of a joint library, by the gathering together of their executive officers under one roof. It is a great thing to be the first to do anything. You can never do anything the first time twice. Therefore, it seems to me that there is an especial significance in our being gathered together tonight for the first time to listen to the first paper to be delivered in the building of the Engineering Societies. It adds especial interest to me, in introducing the speaker of the evening, that he should, in addressing the Society of Mechanical Engineers on the subject allotted to him, address us as an associate member of the Institute of Electrical Engineers, emphasizing in that position of his, and in his relation tonight as our speaker, the fact that we are coming together in one under the roof of the Engineering Societies.

After the address a full opportunity is to be given for the inspection of the building. The suggestion is made that you should go to the top of the buildings, which is the library area, and then to the floor of next but one below, the eleventh floor, which is the floor of The American Society of Mechanical Engineers, and then follow on down through the smaller auditoriums on the level above this. It is supposed that this room holds about one thousand when fully seated, but there are smaller auditoriums on the floors above which are also ready for occupancy by the organizations who want to use areas of that size. We ask your inspection of the smaller rooms.

In introducing Mr. Fish as the speaker of the evening, I introduce him as an associate of the Institute of Electrical Engineers, as the President of the Telephone Company, as a lawyer who has given careful and exhaustive study to the problem on which he is to address us, and as a man capable of broad views on any subject submitted to him."

OBITUARY

WILLIAM PAINTER

William Painter was born in Philadelphia, November 20, 1838. He adopted the profession of mechanical engineering in 1861, and from that time interested himself in inventions with the result that before his death he received nearly one hundred patents.

In 1882 he began inventing appliances used in bottling, and perfected the crown cork, loop seal, and the aluminum bottle stopper, as well as the machinery used in their manufacture. Mr. Painter was secretary and general manager of the Bottle Seal Company from 1882 until 1892, at which time the Crown Cork Seal Company was incorporated as the successor of the Bottle Seal Co. He continued in the position of secretary and general manager until January, 1903. Mr. Painter was a member of the American Institute of Mining Engineers, a life member of the Maryland Academy of Sciences, and a prominent and active member of several Baltimore clubs. He had been ill since June 1, and died July 15, 1906, at the Johns Hopkins Hospital.

SIR EDWARD J. REED

Sir Edward J. Reed, K.C.B. and M.P., died November 30, 1906. He was born in 1830 at Sheerless, Kent, England, and educated at the School of Mathematics and Naval Construction at Portsmouth. Sir Edward received his appointment as Chief Constructor of the British Navy in 1863, but at the end of seven years resigned because he did not favor rigged sea-going turret ships which were then so much in favor. From 1874 to 1895, he was a Member of Parliament and was made Lord of the Treasury in 1886. At one time he was editor of "The Mechanics Magazine." He was author of several books, notably "The Stability of Ships" and "Modern Ships of War;" was Vice-President of the Institute of Naval Architects, and a former member of the council of the Institution of Civil Engineers. Sir Edward was elected an Honorary Member of the American Society of Mechanical Engineers in 1882.

OBITUARY

CHARLES THOMAS BAYLESS

Charles Thomas Bayless was born in Louisville, Ky., September 2, 1871. He prepared for college at Louisville Rugby School, and later entered Stevens Institute of Technology, receiving the degree of M.E. with the class of 1893. He was an instructor during the supplementary term at Stevens Institute, 1893; and was with Mr. David L. Barnes, consulting engineer, of Chicago, 1893–1896. He went to New Mexico in 1896, as chemist in the smelter at Chloride. He entered the employ of the Mexican Central Railway, City of Mexico, in 1897, as draughtsman in the motive power department. In 1899, he was made chief draughtsman, and on September 1, 1901, was appointed mechanical engineer. While there, he had charge of design and equipment and general railway work. He was a member of the Railway Club of Mexico, and became a member of the Society in 1896. He was a member of Beta Theta Pi and Theta Nu Epsilon fraternities, Past Master of the Toltec Lodge No. 214, Free and Accepted Masons, City of Mexico, and a member of the Royal Arch Masons. Mr. Bayless died September 5, 1906 in Aguascalientes, Mexico.

MICHAEL JOSEPH DALY

Michael Joseph Daly was born in South Norwalk, Conn., December 20, 1840. His early work as a mechanic was with Pitkin Bros. & Co. of Hartford, in charge of important contracts. In 1882 he began business for himself with a limited capital, but gradually the small works became prominent in mechanical construction in New England, mainly in steam plants for churches, libraries, and similar institutions. Mr. Daly was active in church and municipal affairs, a member of the Master Steam Fitters' Association, and has been a member of the Society since 1899. His death occurred in Waterbury, Conn., January 11, 1906.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both as to positions and as to men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 20th of the month. The list of men available is made up entirely of members of the Society and these are on file, with the names of other good men, not members of the Society, capable of filling responsible positions, information about whom will be sent upon application.

POSITIONS AVAILABLE

014 Works manager for two machine shops operated by same company, one in the east and one in the west. Must have had considerable general experience. Executive and organizing ability required.

015 A manufacturing concern 75 miles from New York wants an intelligent man to take charge of its furnaces; man must have executive ability and be able to get results. One who has had experience in blast furnace or similar work preferred. Adequate salary.

016 Moderate sized machine shop with thoroughly up-to-date equipment, building Corliss and gas engines, desires superintendent. Must be a man with the necessary education and fair amount of experience, who is a good organizer. Location, Middle West.

017 Massachusetts concern desires services of a number of tracers, draftsmen, and engineers.

018 Head draftsman; extended experience in machine design and shop practice; neat, methodical, good organizer and controller of men. Location, California.

MEN AVAILABLE

20 Cornell graduate; extensive experience in design and construction of sugar factories and refineries, securing of contracts, designing heavy machinery, construction, erection, and starting of same. Also executive experience.

21 Engineer desiring position as structural draftsman, designing or in charge of a squad in New York City or vicinity.

22 Graduate of Cornell, '92; age 37, married; 15 years experience in engineering as draftsman, designer, superintendent, consulting engineer and salesman. For the last 5 years with large engine and mining machinery works, part of that time as assistant to superintendent of construction. Location in mild climate.

23 Mechanical and electrical engineer, 30 years of age, manual training and technical graduate; 4 years practical experience in machine shop, 7 years in drafting rooms of large concerns, having charge of same for 6 years, including estimating work; desires executive position in or near Philadelphia.

24 A business mechanical engineer, member, at present employed, desires to make a change. Thirteen years as consulting engineer and trouble man for large manufacturers. Expert in the use of steam for power and manufacturing purposes, and hydraulic power plants. Designed, installed, and operated power plants, manufacturing plants. Organized selling departments and appointed agents in the United States and Europe. European experience in labor, raw materials, agents, and selling.

25 Mechanical engineer, 35 years of age, thoroughly up-to-date automatic machine and tool designer, jigs, fixtures, punches, and dies; wood and metal patterns, limit gages for interchangeable manufacture, mill and factory construction and equipment, desires change. Practical and technical experience, executive ability and can produce results. References from past and present employers.

26 Position as superintendent or assistant by member of 25 years experience in varied lines of manufacture. Has successfully held such positions. Situation in the east preferred. Salary $2500.

27 Technical graduate desires a change; 32 years old, experienced in drafting on engines, mill, and factory arrangements, and on power plants. Has had experience in field construction and engineering office work on power plant installations.

28 Member. Age 41. Steam and mechanical engineer with very extensive practical experience in steam engineering, marine and stationary, desiring to make a change, would accept position as superintendent of motive power, or engineer-in-chief where engine and boiler room economies are essential. Over six years in present position as steam and engine expert with large concern. Extensive mechanical and inventive ability.

29 Position as superintendent or works manager wanted by technical graduate who has had extensive experience in the practical management and organization of machine shop and foundry. Successful with handling men. Now holding responsible position where he has reorganized a well known manufacturing plant and is making it pay.

30 Graduate Yale and Cornell, has held position as works manager, chief engineer, and executive engineer in prominent companies in the United States and England, desires position along similar lines, preferably in New York.

31 Technical graduate, 25 years old, with 3 years' experience in office work of engineering and manufacturing plant, and in handling men, desires position with manufacturing or contracting concern.

32 Mechanical engineer, 12 years practical experience in shops. Technical graudate and thoroughly competent. Position as superintendent or manager of manufacturing lines preferred.

33 Junior member; Cornell graduate; experience in shops, gas engine building and electrical apparatus work. Desires position as engineer, assistant engineer or assistant superintendent or in sales line closely connected with engineering.

34 Junior member. Two years sales of machinery and supplies to railroad and industrial custom east of Pittsburg. Four years' railroad experience from shop to assistant master machanic. Graduate of Massachusetts Institute of Technology. Now at top of present concern.

35 Chief draftsman with experience in design of large and small gasolene engines for cars, trucks, and other vehicles, desires position as mechanical engineer or assistant superintendent in same line of work. Technical graduate, six years' practical experience. Associate member.

CHANGES OF ADDRESS

AHARA, Edwin Hugh (1906), Genl. Supt., Dodge Mfg. Co., Mishawaka, Ind.

ALLEN, Carleton Brigham (Junior, 1905), Asst. Supt., Marine Constr., N. Y., N. H. & H. R. R., Harlem River, New York, and *for mail*, 30 Colonial Pl., New Rochelle, N. Y.

ANDERSON, Leslie Douglass (Associate, 1906), 24 South State St., Salt Lake City, Utah.

BARBOSA, Arthur Silverio (1906), Mech. Engr., Escriptorio da Linha, E. F. C. B., Rua Senador Pompeu 268, Rio de Janeiro, Brazil.

BATEMAN, Edward L. (Associate, 1897), Mgr. for So. Africa of Allis-Chalmers Co., P. O. Box 6659, Johannesburg, Transvaal, So. Africa.

BOYD, John J. (Associate, 1906), Pres., Hudson Engineering & Constructing Company, 92 William St., New York, N. Y.

BUFFUM, F. D. (1902; Associate, 1904), Gary, McDowell County, W. Va.

BURBANK, Louis Stelle (1898), Mech. Engr., 175 Beacon St., Worcester, Mass.

CATLIN, Abel Delancy (Associate, 1906), Pres., Chattanooga Machinery Co., Chattanooga, Tenn.

CHILDS, Eugene (1899), Treas., Fresno-Belvoir Mining Company, 112 School St., Roxbury, Mass.

CHURCHILL, Wm. W. (1892), Monroe, Wis.

CULLINGWORTH, Geo. R. (1884), Mech. Engr., Garvin Machine Co., Spring and Varick Sts., New York, N. Y.

DE LAMATER, Oakley R. (1902), 1787 Broadway, New York, N. Y., and 38 Church St., Englewood, N. J.

DIXON, Horace Harcourt (1904; 1906) Mech. Engr., Pres. Dixon Steam System Co., Chicago, Ill., and Dixon & Heydonn, London, and *for mail*, 88 St. James St., London, S. W., England.

DOANE, Wm. H. (1885), 601 Fourth National Bank Bldg., and 2223 Auburn Ave., Cincinnati, O.

DREYFUS, Edwin D. (Junior, 1905), Engr., Allis-Chalmers Co., Godchaux Bldg., New Orleans, La.

EASTHOPE, Joseph (1906), Master Mechanic, Illinois Steel Company's South Works, and *for mail*, 7534 Saginaw Ave., Chicago, Ill.

FORGY, J. Edmonds (Junior, 1906), Construction Dept., E. I. du Pont Co. Wilmington, Del.

FRECHTLING, Arthur George (Junior, 1906), care Fairbanks, Morse & Co., Cincinnati, O.

FREEMAN, Stuart, E. (1896), care A. S. M. E., 29 West 39th Street, New York, N. Y.

GALLAGHER, Robert Thomas (1906), Ch. Draftsman and Designer, Eng'g Dept., Amer. Steel & Wire Co., and *for mail*, 12 Huntingdon Ave., Worcester, Mass.

GARDNER, Henry (Junior, 1904), with H. K. Porter Co., 49th St., and *for mail*, Cornell Apartments, Thomas St., Pittsburg, Pa.

GRAY, John Wilson (Junior, 1895), Representative, Newport News Shipbuilding & Dry Dock Co., Newport News, Va.

GREENLEAF, George Edward (1892), Mech. Engr., Niles-Bement-Pond Company, Plainfield, N. J.

GUMP, Walter B. (Junior, 1902), Designing Engr., The Cleveland Construction Company, 606 Citizens Building, Cleveland, O.

HADEN, Harry Y. (Associate, 1906), Mgr. Philadelphia Office, Dravo, Doyle & Co., Engrs. and Contractors, Arcade Bldg., Philadelphia, Pa.

HALE, Robt. Sever (1894; 1897; 1899), Genl. Agent, Edison Elec. Ill. Co., 3 Head Place, and *for mail*, care Tennis and Racquet Club, 925 Boylston St., Back Bay, Boston, Mass.

HALL, Morris Albert (1905; Associate, 1906), Chief Draftsman Motor Car Dept., Sheffield Car Co., and *for mail*, Lock Box 103, Three Rivers, Mich.

HARDING, Adalbert (Junior, 1898), care The Westinghouse Machine Company, 10 Bridge St., New York, N. Y.

HARMAN, William Henry (Associate, 1906), Mech. Engr., Camden Iron Works, Camden, N. J.

HARRIS, James Wilfrid (1905), Engr., Dominion Iron & Steel Co. Ltd., Sydney, Nova Scotia, Canada.

HECK, Robert C. H. (1906), Lehigh University, South Bethlehem, Pa.

HERING, Rudolph (1906), Life Member; 170 Broadway, New York, N. Y.

HOGLE, Milton Ward (1901; Associate, 1906), Mech. Engr., 1065 Frick Bldg. Annex, Pittsburg, Pa.

HONSBERG, August A. (1901), Engineers' Club, 716 Caxton Bldg., Cleveland, O.

HUDSON, Wilbur Gregory, (1906), Supt. Construction, Link Belt Company, Nicetown, Philadelphia, Pa.

HULBERT, William Rowsell (Associate, 1906), Managing Editor, "Compressed Air", 108 Fulton St., New York, N. Y.

HUNT, Leigh Anson (1906), President, Hunt Engineering Company, Iola, Kan.

JONES, Jarrard E. (Junior, 1903), Warrant Machinist, U. S. F. S. West Virginia, U. S. Asiatic Fleet, and *for mail*, 251 Greene Ave., Brooklyn, N. Y.

LAIRD, Wilbur Goodspeed (Associate, 1906), 60 Wall St., New York, N. Y.

LANE, Henry Marquette (1900), Cons. Fdy. Engr. and Metallurgist, 1137 Schofield Bldg., Cleveland, O.

LANGER, Paul (1906), Prof. Techn. Hochschule, Aix la Chapelle, Germany.

LORING, Charles H. (1882), Chief Engr., U. S. N., Hotel Clarendon, Hackettstown, N. J.

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THE ETHICS OF TRADE SECRETS

By FREDERICK P. FISH, ESQ.

The trade secret that interests us today as a practical and substantial feature of our industrial relations can not be considered apart from the law which defines it and alone determines its extent and character as a thing capable of discussion. In so far as such a secret is protected, it may be regarded as a species of property. It is, however, obviously not tangible property, like lands or chattels. It is not even of the class represented by stocks, bonds, or other securities. Its legal recognition implies a right to a thing that is intangible; to an idea or plan. In this respect, it may be compared not only with property in inventions, in so far as the same are protected by letters patent, but with the limited rights which an author has to his literary productions, and the artist, musician, or playwright to the creations of his imaginative effort. Trademarks, and the right to check unfair competition which has grown out of the trademark law, are other forms of intangible property which the law protects.

2 It is only at a comparatively high stage of development in a community that the law recognizes and deals with such intangible rights. Early jurisprudence is largely concerned with personal rights and with tangible property. It is filled with provisions as to the maintenance and support of the complicated relations which in primitive times characterized family, social, and political life. As society advances, the idea of individualism develops, and freedom of action is encouraged. As pointed out by Sir Henry Maine, "contract," that is, relations voluntarily established by individuals, becomes more and more important, and "status," which is the condition imposed upon the individual by his environment, that is to say, by the accident of his having been born in a certain station in a certain community and at a certain time, becomes less controlling.

3 This change from status to contract has clearly characterized the development of the English speaking race to which, as a matter of institutions if not altogether of blood, we belong. Involved in it, has been a growing recognition of the right of a man to that which

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was his own. This was inevitable if individual effort was to be fostered and men were to be free to deal with each other by contract. If public sentiment requires that the effort of each citizen shall be encouraged to the utmost and that no one shall have the direct benefit of another's contribution to productive power without his consent, it is inevitable that the familiar doctrine of property rights should be extended so as to include things, some of them of great value, which in an earlier social organization were not conceived of as subject to a legally protected individual ownership.

4 We all know how astonishing have been the advances in material prosperity during the hundred years last past. He would be a bold theorizer who would contend that this advance has not been due, in part at least, to the fact that during all that period individual initiative has been fostered by public sentiment, and by the law which in the long run reflects the prevailing public sentiment.

5 It is during this hundred years that the right to the intangible properties to which I have referred has for the most part been crystallized into such shape as to be capable of definite expression. Letters patent for inventions, to be sure, grew out of the exception in the Statute of James I. (1623–1624), which declared monopolies, so long a source of revenue to the British kings and of hardship to the subjects, to be illegal except when granted for a limited term for a new manufacturer; but the important development of patents and of patent law as an essential part of the prevailing industrial scheme, did not really begin either in Great Britain or in this country until well into the 19th century.

6 In 1742, the great Chancellor, Lord Hardwicke, declared that while every trader had his distinctive mark or stamp, he knew of no precedent for enjoining one trader from using another's mark, and he thought such precedent would be mischievous. In 1803, such a precedent was established by Lord Eldon, in the case of Hogg v. Kirby, 8 Ves. 215. From this time the law grew rapidly. Its progress has been especially marked during the past thirty years.

7 The definite development of the law of copyright, both that which is based on statute and that which is independent of legislative enactment, is in like manner comparatively modern. The first trade secret case was decided less than one hundred years ago.

8 In all the classes of rights to which I have just referred, there is this common: Ideas or thoughts or plans or schemes which are of value to the one who rightfully possesses them, are secured to him to a greater or lesser extent by the law. In the case of a trademark, and of the cognate law preventing unfair competition, what is secured

to the owner is a monopoly of the benefit which comes from the impression associated with the shape or appearance or brand of an article of manufacture which, lingering in the mind of the buyer, influences him in subsequent purchases to take what he believes to be goods of the same make as those which he bought before. There is a special analogy between trade secrets and letters patent for inventions on the one hand and common law and statutory copyright on the other. I shall again refer to this.

9 The trade secret, as we know it, as defined and determined by our rules of law which alone give it body and character is, therefore, a comparatively modern institution. But there was a long history of trade secrets prior to our common law recognition of them. It may be interesting to note briefly the great part that they have played in the industries under conditions that have now passed away.

10 In all ages many trade secrets have been in the possession of individuals, but for a long period of time they also were a great asset of trading communities and frequently of guilds or associations. Every effort was made to preserve them for the few who had the benefit of them. Always and everywhere those who did not have the secrets sought to learn them. While not as a rule protected by systematic rules of law, kings and governments often intervened to aid their subjects to preserve the secrets they had, and to learn those which they did not know. All this was in accordance with the underlying laws of human nature which prevail even to this day. It was a phase of the struggle for advancement that has characterized all progress. As in all other phases, the struggle was carried on by each generation according to the standards of the time, and those standards were sometimes not high. It seems clear, however, that the right to preserve a trade secret if one could, and to an equal degree the right to get the secret of another by any means not offensive to the current moral sense, were always recognized.

11 The history of the silk industry, up to a comparatively modern time, was largely confined to the disclosure of the secrets of the East to the people of the West, and later of one Western community to another. The mysteries of cloth manufacture and of dyeing were jealously guarded all through the Middle Ages. There are dramatic stories of the way in which such secrets were carried from one place to another. We read of James I. of England smuggling three skilled workmen in hogsheads from France to instruct his British subjects in the secret process of manufacturing the alum used in dyeing.

12 Many community trade secrets were disseminated by the religious persecution of the 16th and 17th centuries which drove

from the Netherlands and from France, Protestant skilled workmen who were in the possession of those secrets. This had much to do with the development of industries in England, Germany and Switzerland. In particular, the revocation of the Edict of Nantes exiled from France thousands of Huguenot workmen, who were thus forced by the action of their own government to introduce into foreign countries secrets of French trade and manufacture, which otherwise might not have been discovered for years.

13 The modern art of hat making prior to the revocation of the Edict of Nantes, had been entirely in the hands of certain of the French Protestants. They alone possessed the secret of the liquid composition which served to prepare properly the hare, rabbit, and beaver skins used in hat making. So many of them were driven to England that the secret of their art was lost to France for more than 40 years, during which time the French nobility and all persons making pretense to elegance in dress, wore nothing but English hats. Finally about the middle of the 18th century, a French hatter, named Mathieu, who was working in London, stole the secret which the refugees had taken away and carried it back to France, where the industry was reëstablished. No greater blow was ever inflicted upon the industries and trade of a nation than in France by the revocation of the Edict of Nantes.

14 The great family of the Medici in the 16th century had a trade secret relating to the manufacture of a soft porcelain, which was subsequently lost, probably because it was too carefully guarded.

15 About the year 1710, John Frederic Böttger, who was in the employ of Frederic Augustus, Elector of Saxony, discovered the secret of making real porcelain. His master, the Elector, resolved that the discovery should remain a trade secret. He therefore kept Böttger in close confinement until his discovery was perfected to the point of finished work. He then established a factory within the fortress of Albrechtsburg. The drawbridge was always raised; none but the workmen could enter or leave the factory and they were bound by a solemn oath to keep until death the secret, if by accident they learned it. They knew that the severest punishment would follow any betrayal. This was the origin of the famous Dresden or Meissen ware. The secret of the Saxon Elector was, however, preserved only for a short time. About 1745, a runaway workman carried it to Vienna, where under royal patronage factories were established to practice it, which have turned out masterpieces of the potter's art. The secret was also carried to France about 1770, when the manufacture of the Sèvres pottery began.

16 Long after the Flemish refugees driven from the Netherlands by the religious persecutions of Philip II. had come to England, they kept to themselves as trade mysteries the manufacture of felt, and the making of certain brass ware for culinary purposes.

17 The establishment of the first glass factory in England was the result of the theft of a trade secret. An English admiral, angered by having been refused admittance to a French factory, hired away one of the workmen from that factory and founded an establishment at Ravenshead, Lancashire, which has continued almost if not quite to the present time.

18 The secrets of the production of Venetian glass ware were guarded with most jealous care. No strangers could learn the art. Any workman carrying his skill to another country was followed and ordered back. If he refused to return, his relatives were imprisoned. If he still persisted, his life was in danger. It is recorded that a wandering Venetian glass maker named Paoli was followed to Normandy, where he was stabbed with a dagger on which was written the word "Traitor."

19 The East, as it always has been, is today a great field for trade secrets. We of the West do not know the mysteries of crackled china, of lace work, translucent porcelain covered with glaze, or of the marvelous egg shell cups and the process whereby they are enameled and covered with a finely woven case of bamboo. The same is true of many processes for the manipulation of metals and amalgams, which are known to the workmen of Japan and by which are produced effects beyond the reach of the workmen of other countries.

20 The two oldest secret trade processes now in existence are said to be the manufacture of Chinese red or vermilion, and the Damascus art of inlaying hardened steel with gold and silver.

21 Up to the capture of the city by Tamerlane, the Damascus blade was the most famous weapon in the world. It could cut iron or gauze floating in the air. Tamerlane carried all the weapon makers of the captured city into Tartary where they continued their work. Their descendants are said to be skilled smiths in Samarcand to this day; but no more of such blades were produced in Damascus. One can buy Damascus weapons there today, but they are mostly "made in Germany."

22 Always and everywhere there has been a constant effort to discover the secrets of rival manufacturers or of rival communities. An interesting story on the subject is that of the Venetian, Braarti, who in the 18th century obtained a knowledge of the methods practiced in the Bohemian Glass Works by disguising himself as a porter

and serving for three years in a glass factory in order that he might take home with him certain mysteries of the Bohemian art that were not known in his native city.

23 The day of the guild or trade association has long passed way. The time has also passed when, except in the East, a state or even an isolated community can hope to monopolize a trade secret which is shared by a substantial number of people. The ties which bind the workmen in any craft to their employer or to any comprehensive trade organization have long been among the Western nations too loose to prevent the dissemination of any trade device or method which is known to a large number of people. It can be no longer a secret if all those working in a trade in any locality are familiar with it.

24 A reference to these trade secrets of the olden time, which seems to have had for the most part no definite legal sanction, is only material as affording a basis upon which public sentiment, with the sanction of the law, has given to us our trade secret of today. The whole industrial world was permeated with the idea of trade secrets and of their value. As the trades became more and more matters of individual enterprise, it was but natural that, with this history behind them, the sentiment of the community regarded them as a substantial thing to be dealt with on grounds of public policy. It has dealt with them, through the law, exactly as it has dealt with copyrights and trade-marks, and I believe in a way that is quite in harmony with the general thought of the time.

25 When our law of trade secrets was first formulated less than a century ago, the industrial conditions were nearly as remote from those of the present day as they were from those of the Middle Ages. The trades had, however, come generally into the hands of individuals. We had started on a line of industrial organization and development which has been consistently followed to the present time. Almost the cardinal principle of this line of development has been the encouragement of the individual to risk and effort. It has been generally recognized that the gain to the community would be the greatest if every member of it was stimulated to do his utmost for himself. There is need for encouragement to individual thought and effort. No one is likely to face the trouble, anxiety, and cost of experimenting and testing new ideas, which are sure to fail in the majority of cases with the chance of great loss, unless he can look forward to a substantial reward if he succeeds.

26 This thought was not new with the last century. It has always existed. Men have always been encouraged to seek individual prosperity as probably the best way to promote the common good. It

may well be that the whole doctrine of the right to property, which seems to us instinctive, rests upon this foundation. But with the expanding manufactures, trade, and commerce of the last hundred years, the idea has become dominant as never before and has been definitely reflected in our institutions and laws. Certainly, there can be as a practical matter, no greater stimulus to the individual to do the best there is in him toward building up the industry with which he is concerned, than the certainty that he may secure and maintain for his own use that which he has acquired fairly and honestly according to the standards of his time, part of which is a just proportion of what he has added to the general productive power. If such is the case, the greatest good of the greatest number must require that there should be a gain to him for his contribution to the well being of the community by way of original thought and initiative, as well as by way of good business methods or administrative capacity or ardent labor.

27 There has never been a time when there were not some dissenters from this general view. Those who have been unsuccessful have sometimes failed to admit its validity. Many have speculated as to whether there were not conceivable industrial conditions, perhaps better than those which prevailed, in which so much encouragement would not be given to the individual but in which the requisite effort could be secured on other and less selfish grounds. And there have been times in which the natural and perhaps inevitable development of current industrial methods has been such as to bring about a revulsion of public sentiment, more or less sound, and more or less justifiable, but at any rate to be taken into consideration as definitely affecting the trend of development of industrial ideas and industrial conditions. But it does not seem possible to deny that the general sentiment has almost always been in favor of the encouragement of the individual in his selfish aspirations for personal prosperity.

28 I see nothing in the temper of our own times to indicate that this broad view of what is for the common good has been shaken. Few doubt that an individual should get a personal benefit from his personal skill and energy. We believe that the better and more useful the workman, the more he should have the rewards of life. The public generally agrees that the more one contributes to the progress of the arts as an inventor, the more he should have for his personal use, and that the reward of the tradesman or manufacturer should be based, to a substantial extent, upon the skill, energy, capacity, and honesty with which he carries on and builds up his business. We know that the entire community profits by the deserved success of any

individual in it. We feel instinctively that if the efforts of individuals are attacked or discouraged, all will suffer. The time may come when different views will prevail, but I do not anticipate that such will be the fact.

29 It has of course always been understood that the gain to the individual should be acquired honestly in accordance with the prevailing standards of the time. Sometimes the community has decided that the prevailing standards were wrong, that is to say, inconsistent with the general welfare. Then the standards have been more or less changed and new ones established, occasionally after marked political and business convulsions, but when the convulsions were over and a readjustment to new conditions attained, it has been found that the right of a man to a fitting reward for his contribution to the public well being was respected as much as ever, and that society instinctively proceeded upon the old principle that individuals must be encouraged to prosper as the best known means of securing to the community the gain in productive power and the progress in industrial effort that was essential.

30 It is upon these fundamental principles that the underlying right to the protection of a trade secret, in so far as it is or can be protected, depends. The right is logical and will be asserted and enforced by public sentiment and by the law, which as I have already said is in the long run a reflection of public sentiment, until we cease to believe that individual effort should be encouraged as the most effective stimulus to industrial improvement. When, if ever, doctrines like those of socialism prevail, many rights which seem to us natural and proper may disappear, among them, perhaps, the right to protection against the disclosure of a trade secret to the extent to which that right now exists.

31 A trade secret is some method of manipulating or combining materials, or of controlling or directing the forces of nature, or of organizing machinery, or the details of a business which is the result of original thought, which is of trade value to the person who has the thought or the right to apply it, and which is kept by him a secret that he may get from it a personal advantage not to be directly shared by his competitors. Let us take the simplest possible case. A manufacturer of dyestuffs, through his own ingenuity or thoughtfulness or through the ingenuity or thoughtfulness of others whom he has employed, finds out that his product can be increased or improved or that he can get a new product by a certain process that is not at the time employed in the art. It is clear that under none of our standards, either of law or of ethics, is the manufacturer under an obligation

to use this process or to disclose it to anyone. I doubt if there can ever be any effective law supporting such an obligation, and in the absence of such a law any sentiment of the community, even if it existed, would be inoperative. Neither the law nor the sentiment exists today.

32 The secret, therefore, is the man's own, to keep or to disclose, to use or not to use, as he pleases. No public policy or law can force its disclosure or use. But the one who has it can be encouraged to disclose it or use it, one or both. The patent law offers a reward for the disclosure of secrets of a certain sort, and incidentally encourages their use. I shall have a word to say later as to the bearing of letters patent on the subject, under discussion. The law relating to trade secrets does not tend to promote the disclosure of them, but the contrary. It does encourage their use.

33 If such a secret is of the slightest value, its use as distinguished from its suppression is obviously desirable. If it is suppressed, no one gets any advantage from it. Who is benefited if it is put into use? Is not the answer to this question clear? The possessor of the secret will get some benefit from its use; but the community as a whole is far better off if the secret is utilized. By practicing the secret, the possessor of it will be getting by a given expenditure of capital and of effort, a new product or a cheaper or a better product. He will get a profit for himself; but not all of the profit; some of it will inevitably go to the public. He will be adding to his own wealth, but he will also be adding to the wealth of the state, of which his own wealth forms a part. His business will prosper; he will employ more workmen; the efficiency of his industry will be enlarged; it will be of more general advantage to the community; the well being of society will thereby be advanced. All this follows whenever there is in an art an improvement which is actually utilized. No argument seems to be required to show that society is better off if the new thing is employed in practice, than would be the case if it were not used at all.

34 The possessor of a trade secret, who need not use or disclose it and who is unwilling to publish it, should therefore surely be encouraged to use it. The law recognizing this fact affords him the only form of encouragement that is really practicable, namely, a certain limited aid in his effort to practice and utilize his secret without losing it. It helps him keep his secret.

35 It has never been suggested that the law should go so far as to protect a trade secret that was not a real secret. Such a proposition is entirely inconsistent with the common sense and intelligence of mankind. However brilliant may be a thought or an idea, whether

it is of value to the industries or to literature or art, when without dishonesty, fraud, or treachery, it has once become known, it is common property. There are men so high minded that they would disdain to use the ideas of others, even if they had the right so to do, but such a view is not universal, and it would be utterly impracticable to seek generally to preserve for one, even if he has originated it, a thought or an idea that has without wrong become disclosed to others, so that it is no longer a secret. But the law can say, to encourage the use of such a secret, that those who are bound by contract or by good faith to aid in keeping it shall be held to their obligation.

36 It is just to this extent and no further that trade secrets are protected. The law does not intervene to protect the secret against discovery by fair and honest means. It does not undertake to make the secret, as such, secure. It only enables it to be utilized, for the good of the possessor and of the public, without danger of betrayal by those who learn the secret in confidence while it is being operated as a secret, and who can betray it only by what the law regards as a breach of honesty and fair dealing.

37 The man who is practising his trade secret must have associates and workmen. Some of them will inevitably learn the secret. Is it not fair and reasonable that, learning the secret under such conditions, they should be forced to respect it? It is by their voluntary act that they enter into such relations. Having established them, should they not be bound by the necessary implication that it was part of the understanding that they should keep what they know to be the valuable secret of the man with whom they are associated? There would seem to be no question in the case of an express contract. Should not a confidential relation clearly involving an implied contract, be equally effective?

38 There may be others, not directly associated with the work, to whom the secret is imparted in confidence. Is it not proper that they should regard that confidence? Does it not appeal to us as right, that those who receive a secret of this sort through a confidential relationship which involves a knowledge of the secret, should respect it and be bound not to disclose it?

39 If the law and public sentiment were otherwise, no trade secret could ever be safely put into use. By holding to what seems to be only a fair standard of business ethics, those who gain a knowledge of the secret through a contract or a confidence that is reposed upon them, are prevented from disclosing it, and the desired result is accomplished. The possessor of the secret is not, to the detriment of the community, tempted to refrain from using it, but he is encouraged

to practice it for the gain there is in it, knowing that so far as he uses it as a secret, those who are in the secret are bound to coöperate with him in protecting it against disclosure.

40 It has been settled by an almost unbroken line of authorities, and it is absolutely clear at the present stage of the law, that a trade secret will be protected against disclosure by anyone who has received it in confidence and under such circumstances that there is a contract, express or implied, that the person to whom the secret was disclosed should himself respect it. It follows that there is also a remedy against those who have received a disclosure of the secret from persons guilty of a breach of confidence or of contract in imparting it, unless they themselves were both entirely honest in the matter and protected by the equities of the situation. Against all others the owner has no redress. He can only invoke the power of the law to make effective an obligation to respect his confidence and to live up to an agreement.

41 The question has most frequently arisen, and is most likely to arise in connection with the employees of one who is actually practising a secret. These men must, from the nature of their employment, know the secret, or be in a position to discover it. In dealing with a case of this sort, an English chancellor, in the case of Morison v. Moat, 9 Hare 241 (21 L. J. Ch. 248), laid down the law in the following words:

> The principles that were argued in this case are principles really not to be called in controversy. There is no doubt whatever that where a party who has a secret in a trade employs persons under contract, express or implied, or under duty express or implied, those persons cannot gain the knowledge of that secret and then set it up against their employer.

42 In Stone et al v. Goss et al, 65 N. J. Eq., 756, the court says:

> These cases establish the principles that employees of one having a trade secret, who are under an express contract, or a contract implied from their confidential relation to their employer, not to disclose that secret, will be enjoined from divulging the same to the injury of their employer, whether before or after they have left his employ; and that other persons, who induce the employee to disclose the secret, knowing of his contract not to disclose the same, or knowing that his disclosure is in violation of the confidence reposed in him by his employer, will be enjoined from making any use of the information so obtained, although they might have reached the same result independently by their own experiments or efforts. We approve the principle thus established.

43 Again in Westervelt et al v. National Paper, etc., Co., 154 Ind. 673, the court says:

> It was the understanding and agreement between appellee and said Taggart that his ideas and inventions and discoveries concerning said proposed machine

should belong to appellee, and it was not contemplated by either party that a patent should be taken out upon anything which he might invent or discover, but that it should be kept a secret. It was a part of the said contract with said Taggart that he should make a complete machine for appellee, and for no other person, and both parties understood by that language that no machine embodying the ideas which said Taggart expected to put into practical form should be made by him for any other person, and his perfected ideas should not be divulged to any other person.

44 Taggart entered the employment of appellee and designed a machine, which appellee completed. Then Taggart entered into a contract with the other appellant for three years to make his machine, and employed the same draughtsmen as appellee to furnish drawings.

It is evident from the authorities cited that if a person employs another to work for him in a business in which he makes use of a secret process, or of machinery invented by himself, or by others for him, but the nature and particulars of which he desires to keep a secret, and of which desire on the part of the employer the employee has notice at the time of his employment, even if there is no express contract on the part of the employee not to divulge said secret process or machinery the law will imply a promise to keep the employer's secret thus entrusted to him; and any attempt on his part to use the secret process, or machinery, or to construct the machinery for his own use as against the master or to communicate said secret to others, or in any manner to aid others in using the same, or in constructing the machinery, will not only be a breach of his contract with his employer but a breach of confidence and violation of duty which will be enjoined by a court of equity. * * *

Under the facts alleged, even if no agreement was made, one would be implied that he was not to disclose the secret of the construction of the machine, or impart any information by which anyone could construct such a machine. He occupied a confidential relation to the appellee, and in such case the law raises an implied contract between them that the employee will not disclose any trade secret imparted to him, or discovered by him, in the course of his employment. A disclosure of such secrets thus acquired is not only a breach of contract on his part, but is a breach of trust which a court of equity will prevent.

45 Perhaps the leading case on the subject in this country is that of Peabody et al v. Norfolk et al, 98 Mass. 452, in which Judge Gray, speaking for the Supreme Court of Massachusetts, stated the law as follows:

It is the policy of the law, for the advantage of the public, to encourage and protect invention and commercial enterprise. If a man establishes a business and makes it valuable by his skill and attention, the good will of that business is recognized by the law as property. If he adopts and publicly uses a trade-mark, he has a remedy, either at law or in equity, against those who undertake to use it without his permission. If he makes a new and useful invention of any machine or composition of matter, he may, upon filing in a public office a description of which will enable an expert to understand and manufacture it, and thus affording to all persons the means of ultimately availing themselves of it, obtain letters

patent from the government securing to him exclusive use and profit for a term of years. If he invents or discovers, and keeps secret, a process of manufacture, whether a proper subject for a patent or not, he has not indeed an exclusive right to it as against the public, or against those who in good faith acquire knowledge of it; but he has a property in it, which a court of chancery will protect against one who, in violation of contract and breach of confidence, undertakes to apply it to his own use or to disclose it to third persons. The jurisdiction in equity to interfere by injunction to prevent such a breach of trust, when the injury would be irreparable and the remedy at law inadequate, is well established by authority.

46 The court then cites a number of the leading cases and concludes by sustaining the right of the court to interfere to protect the disclosure of a trade secret where there is a "violation of contract and breach of confidence."

47 This doctrine is supported by practically an unbroken line of authorities. It is like the doctrines of the common law which protect trademarks, and which prohibit the pirating of unpublished dramatic performances, the publication of letters without the consent of the sender, and many other violations of fundamental and personal rights. It is based upon the conception by the courts of what is for the public interest and what is fair, proper, and honest, as between man and man. There always has to be a legal ground for the application by the courts of a principle of sound morals, and in this connection there is some question in the cases as to whether a trade secret is to be protected as property or because there is a contract, express or implied, or because the disclosure would be a breach of trust.

48 It does not seem profitable at this time to enter upon a discussion of these refinements. For all practical purposes, the views of the courts are based upon a single and simple proposition. An individual is justly and honestly in possession of what is a real trade secret, that is, something useful in his business that is known to him and protected by him to the extent of his power as a secret of his trade. There seems no doubt that this is a real property interest exactly as an invention is property to such an extent that the government can make a contract with reference to it by which it is protected for a limited term by a patent, and exactly as an artistic or literary expression is protected as property. In any event, it is obviously unfair that those who have entered into a fiduciary relationship with the possessor of the secret, or who by express contract or by reason of a relationship necessarily implying a contract, have agreed to protect the secret, should undertake to rob the owner of his secret by communicating it to others or using it themselves. The necessity of resenting and checking such unfairness must appeal to all of us as it has invariably appealed to the courts.

49 In a large number of the cases that have been before the courts, there has been no express agreement to protect the trade secret, but only a necessary implication that such an agreement existed, because of the relation of service, or confidential association. As the court said in Robb v. Green (1895), 2 Q. B. 315:

> Where the court sees that there is a matter of this kind which both parties must necessarily have had in their minds when entering into a contract, that is precisely the case in which it ought to imply a stipulation.

50 In Merryweather v. Moore (1892), 2 Ch. 518 (Ch. Div.), the English court said:

> It is sometimes difficult to say whether the court has proceeded on the implied contract or the confidence, for I will put aside once for all any cases arising on express contract. Perhaps the real solution is that the confidence postulates an implied contract; that, when the court is satisfied of the existence of the confidential relation, then it at once infers or implies the contract arising from that confidential relation—a contract which thus calls into exercise the jurisdiction to which I have referred.

51 It is one of the glories of the common law that common fairness and common honesty are at the basis of most of its rules. Occasionally a new situation arises in which the law finds itself so hampered with the technicalities inherent in any definite system of jurisprudence as not to be able to deal as it would like with the new state of facts that have arisen. This is almost always because the state of facts is so radically new. It is one outside of the ordinary trend of the law. When such instances arise, the time for legislation has come.

52 But the courts have had no difficulty in the case of trade secrets. Recognizing the propriety of the proposition that they should be protected in cases where breach of confidence or breach of contract was involved, exact and well-defined principles with which the law was familiar led to intervention by the courts, to see that that was done which was right.

53 While such cases ordinarily are brought in Courts of Equity, because, as a rule, an injunction is sought, an action at law may be brought for damages.

Robb v. Green (1895), 2 Q. B. 315.

54 The injunction will run, not only against the employee, but a against those who, with knowledge of the confidential relations, have induced him to betray the secrets.

Morison v. Moat, 9 Hare 241.

Stone et al v. Goss et al, 65 N. J. Eq. 756.

Taylor Iron and Steel Co. v. Nicholas et al, 61 Atl. Rep. 946.

55 The vendee of the secret has the same right as the inventor of the secret and may bring a bill against a former employee of the vendor, who acquired the secret in confidence before the sale, provided the employee attempts to divulge the secret wrongfully.

Cincinnati Bell Fdry. Co., v. Dodds et al, 19 Weekly Law Bull. 84 (Super. Ct. Cin. O.)

56 The following are some of the cases in which the law as above stated has been enforced:

Plans of engine:

Merryweather v. Moore (1892), 2 Ch. 518.

Patterns of plaintiff's pumps:

Tabor v. Hoffman, 118 N. Y. 30.

Machinery for making gunny cloth by a secret process:

Peabody v. Norfolk, 98 Mass. 452.

Medicinal formulæ:

Hartman v. Park & Sons Co., 145 Fed. Rep. 358.

C. F. Simmons Med. Co. v. Simmons, 81 Fed. Rep. 163.

Weston v. Hemmons, 2 Vict. Law Rep. 121 (1876).

Yovatt v. Winyard, 1 Jacob & Walker 394.

Morison v. Moat, 9 Hare, 241.

Green v. Folgam, 1 Sim. & St. 398.

Processes and formulæ for manufacturing photographic supplies:

Eastman Co. v. Reichenbach et al, 20 N. Y. S. 110; 29 N. Y. S. 1143.

Process for making typewriter ribbons:

Little v. Gallus et al, 38 N. Y. S. 487.

Process for making sticky fly paper:

Thum Co. v. Tloczynski, 114 Mich. 149.

Secret process for making steel:

Taylor Iron and Steel Co. v. Nichols et al, 61 Atl. 946 (N. J. Eq. 195).

Secret process for detinning tin scrap:

Vulcan Detinning Co. v. American Can Co. et al, 67 N. J. Eq. 243.

Reversed on other grounds, 62 Atl. 881.

Secret process for the manufacture of compounds for removing hair and wool from hides:

Stone v. Goss et al, 65 N. J. Eq. 756.

Machine for making paper boxes:

Westervelt et al v. Nat. Paper and Supply Co., 154 Ind. 673.

Secret for dyeing cloth:

Bryson v. Whitehead, 1 Sim. & St. 74.

57 Many other trade secrets which are in their nature commercial, that is, business plans or devices, which were special to one who possessed them, and useful in his trade, have been in like manner protected by the courts. Examples of these are shown in the following cases:

News agency contract, by which the plaintiff sent news to its subscribers under contract not to divulge it is enforced in equity:

Exchange Tel. Co. v. Central News (1897), 2 Ch. 48.

Contracts of a commercial house must be kept secret by a clerk:

Hamlyn v. John Houston & Co. (1903) 1 K.B. 81.

See Salomon v. Hertz, 40 N. J. Eq. 400.

Forms and materials for printing advertisements in plaintiff's publication cannot be used by his agents for a rival publication:

Lamb v. Evans (1892), 3 Ch. 462. Aff'd (1893), 1 Ch. 218.

Confidential attorney's clerk enjoined from publishing extracts from books and papers of his employers or of their clients.

Evitt v. Price, 1 Sim. 483.

Although a law pupil has a right to retain copies of precedents in a barrister's or conveyancer's office, see

Merryweather v. Moore (1892), 2 Ch. 518, 525.

Order books containing customers' names cannot be copied by an employee to use later in his own business for soliciting orders:

Robb v. Green (1895), 2 Q.B. 315.

Tailor's assistant cannot take away patterns of clothes of employer's customers when he sets up for himself in order to induce those customers to resort to him:

Lamb. v. Evans, (1892), 3 Ch. 462, at p. 468.

58 Analogous cases which throw light on the principle are the following:

One who makes copies of a drawing under contract cannot make extra copies to sell in competition:

Tuck & Sons v. Priester, 19 Q. B. D. 629.

See Levyeau v. Clement, 175 Mass. 376.

A photographer who takes a photograph to furnish customer with copies cannot sell or exhibit extra copies:

Pollard v. Photographic Co., 40 Ch. D. 345.

Moore v. Rugg, 44 Minn. 28.

See otherwise, Corliss v. Walker Co., 64 F. R. 280, where the customer is a public person.

59 Perhaps as comprehensive a statement of the general law as any is that of Mr. Justice Story in 2 Story's Equity, Sec. 952, as follows:

Courts of equity will restrain a party from making a disclosure of secrets communicated to him in the course of a confidential employment. And it matters not, in such cases whether the secrets are secrets of trade or secrets of title, or any other secrets of the party important to his interests.

60 The doctrine of these cases was first advanced something less than one hundred years ago. In two early cases Lord Chancellor Eldon refused relief. In one (Newbery v. James, 2 Merivale 446), because he did not see how he could pass upon the question without bringing out the secret in the court proceedings, in which case it would be disclosed and therefore cease to be a secret. The courts have been able to deal with this difficulty.

61 In the second case (Williams v. Williams, 3 Merivale 157), he refused relief, first because the defendant in his answer, denied that there was any secret, and, second, because he did not feel that the particular medicinal secret involved was of such a character as to entitle the plaintiff to the good offices of a court of equity.

62 In a third case, however (Yovatt v. Winyard, 1 Jacob and Walker 394), (1820), he granted the injunction asked, and the law has been practically settled since that time.

63 In some respects, the law of trade secrets does not seem quite complete. There have not been sufficient cases arising under sufficiently varying conditions to enable all aspects of the law to be worked out.

64 For example, under the decisions of the courts there seems to be practically no limit as to the character of the subject matter which may be treated and protected as trade secrets. They may be of small or large importance; they may or may not involve great novelty or real inventive quality. They may be mere business expedients which have a trade value because of their convenience, or because they record useful information. Unlike a patentable invention, it does not seem necessary that they should be "new" as well as useful.

65 One eminent judge has decided that a trade secret which had actually been described in an expired patent (there being no evidence that it had ever been practiced) was entitled to protection (Benton v. Ward, 59 Fed. Rep. 411–413). At first sight, it might seem that all that was required was that there should be a secret plan or method or device of any kind, to entitle its possessor to the limited protection which the law gives.

66 I doubt, however, if such is ultimately determined to be the law. When cases arise which require a close analysis of the question, it is probable that the courts will decide that there is something necessary over and above the mere question of secrecy to justify the

exercise of the power of the court to prevent the use or disclosure by one who acquired his knowledge in confidence or while under contract.

67 An employer may have a certain routine in dealing with his help, which he thinks aids him in his relations with them. He may give them certain favors that they appreciate. Can things like these be a trade secret which the law will protect? He may have discovered that a certain make of lathe or of sewing machine is better adapted to the work of his factory than any other. Can not an employee who leaves him, fairly take away that information and use it as part of his stock of trade? There must be some limitation to the things that can really be treated as trade secrets. Exactly as the courts have been forced to determine in special cases whether or not an alleged invention had patentable quality or was merely the result of the intelligent exercise of the skill of the art, so they will probably at some time determine that it is not everything which a man originates or acquires and uses for his own advantage, which is capable of becoming the sort of a trade secret which is entitled to protection. Just where the line will be drawn can not be forseen. It may be that a distinction will be made between those things that come into the art by a mere small dvelopment of old ideas and the exercise or ordinary trade knowledge and skill, and those that result from some degree of original thought, even if it is not of the grade which under the narrow terms of our statutes is required to constitute patentable inventions. It seems clear that as long as the present views of the courts prevail, many things will be protected as trade secrets which could never be the subject of letters patent.

68 Again, it does not seem as if a device or method or plan should be respected as a trade secret unless it is specific in its character and capable of exact description. It is not reasonable that vague general methods or indefinite, ill appreciated peculiarities of procedure should be dignified as capable of becoming in effect property.

69 The decisions have but little to say on such points. The issues in the decided cases have been too clear to make it necessary to develop them. Some time considerations like these will come up in special cases and the law will be started on a line of discrimination and distinction which will ultimately define the limitations, if any should exist.

70 Certain other propositions which are not very explicitly developed in the decisions of the courts or in the text-books, in my opinion are or ought to be a part of the law.

71 It is well settled that the alleged secret must be a real secret.

I believe, however, that before the courts should intervene to protect an alleged trade secret it should appear that it was not only regarded as a secret, but that it was distinctly treated and carefully guarded as such by the possessor of it. It should not be enough that he has had it in mind to call it a trade secret, if he ever needed to invoke the protection of the law. He must have taken all necessary and reasonable precautions to prevent its disclosure. Moreover, it does not seem proper that he should have redress against his employees and associates unless it is made to appear that they knew, while occupying the fiduciary relation which gave them the opportunity to learn the secret, that the specific thing now called a secret was in fact regarded and treated as a secret, which they must respect for all time. It should not be enough that one man has worked for another. The employee has a perfect right to grow with his experience. He has a right to carry away for general use everything that he learns in his place of employment, except trade secrets. The public interest requires this as much as it requires that trade secrets should be respected. The employee or associate should be notified of the exact trade secret, that he may know what results of his experience he can and what he cannot take away and use freely. Eternal vigilance and definite effort should be one price of the investment of a trade secret with any of the qualities of property.

72 With these qualifications, some of which are perhaps not yet fully elaborated in the opinions of the judges, there seems no reason to doubt that the law is thoroughly consistent with sound ethical principles. It is based on a view of what is for the interest of the community, which has commended itself to the judgment of mankind from the beginning. In its application, it insists only on loyalty and good faith, loyalty to one's employer and one's associate and to one's word, and the plain, good faith which is always expected where contract or fiduciary relations are established.

73 To test this question, let us suppose the law to be suddenly changed, I can conceive of only few directions in which a change of any moment is possible. One would be to the effect that the possessor of a trade secret should publish it to the world so that all might have the advantage of it. Such a law would be incapable of enforcement, for the man who has a thought or an idea cannot be forced to express it. If the rule were established that one who practices his thought or his idea, thereby irrevocably gave it to the public, trade secrets would perhaps be eliminated to a large extent, and so would any progress in the art that is based upon them, for the possessors of them would have none of the stimulus to develop them into practical form and

make them useful and profitable, that is based upon the chance of monopolizing them. Surely, this would result in no benefit to the community.

74 Again, the law might be modified so as to remove the present restrictions against the disclosure of a trade secret by one who thereby is guilty of a breach of trust or of contract. So long as we maintain our present standards of right and wrong, so long as we value and insist upon loyalty and good faith, would not such a change in the law be inconsistent with all that is good in human nature, and the application of a principle which is most distinctly immoral? If an employee or trusted associate, for selfish ends, can be disloyal in the matter of a trade secret known to him as such, and the knowledge of which he would never have acquired except through his relation to the possessor of the secret, why should he be loyal in any other matter? It is conceivable that disloyalty as to a trade secret might be the most serious conceivable blow to the one who had given confidence, expecting honesty and fair dealing in return. I trust that the day will never come when the courts will find it necessary to modify in this way a principle of law which to so great an extent emphasizes good faith, which depends so much upon a recognition of the obligation to keep agreements, which is founded upon a sound public sentiment and the underlying virtues of loyalty and fair dealing.

75 It is somewhat surprising that apparently there is no reported case in which an effort has been made to invoke the aid of the courts to protect a trade secret which has been stolen by an outsider. It probably has happened many times that a formula has been copied or a secret found out by one who was not in confidential relations with the possessor of the secret but who got the information surreptitiously. It is quite conceivable that a mere trespasser or a thief should discover such a secret. If such instances were to arise, it seems to me not improbable that the law would interfere to prevent the disclosure of the secret by the one who stole it and its use by any to whom the thief disclosed it. It could not do so, however, on the ground of breach of confidence or breach of contract. The courts would have to base their intervention on some other ground consistent with the general principles of law.

76 In the case of Yovatt v. Winyard, to which I have already referred, a formula had been copied surreptitiously, but it was by one having contract relations with the possessor of the secret.

77 Speculation as to how the courts would deal with such cases is not relevant to the general subject of this paper.

78 Believing as I do that the law of trade secrets is fundamentally

right and in accord with sound ethical and social principles, at least as gaged by our present standards, I have not turned aside to consider the possible objection to the views that have prevailed. It seems to me that those objections are largely upon a consideration of the obvious hardships involved in the situation. It is a burden that one who knows a useful thing should not have full power to utilize it. Is not this true of every legal restriction upon the individual? It is often a serious matter for one to carry out a contract. From a narrow and material point of view, it is frequently disadvantageous to keep faith and respect confidence. Every property right implies that something is monopolized by one or by a few that many others would like to have. The hardship in not being able to utilize knowledge of a trade secret, obtained by way of confidence or contract, express or implied, is no different from that resulting from a multitude of other obligations that are constantly arising, some from our voluntary acts and others from the restrictive operation of laws and usage that have been developed for the common good and which are forced upon all of us whether we like it or not.

79 It must not be forgotten that no man need place himself under the embarrassment of knowing a trade secret unless he chooses. Each of us is free to refuse the employment or the relationship or the contract from which such knowledge would come. If we do not refuse, we must, as in all other relations in life, accept the situation as a whole, with its burdens as well as its advantages. There is nothing special as to trade secrets in this regard.

80 Neither must it be forgotten that the right to protection in the use of a trade secret is a general right. It is sometimes suggested that while the rules of law, as I have defined them, were adapted to a former condition of things, they are not in harmony with our present industrial situation. I do not think that such is the case.

81 It is true that in the early years of the last century, when the trade secret of today, in its legal relations, was formulated by the courts as a logical development of the general principles of law, the units of trade were small. Trade secrets were then in the possession of small manufacturers, for there were no large ones. They were often heir-looms, passing from father to son, for generations. We all know how conditions have changed. In so far as trade secrets play any part in our industries of today, they are necessarily, to a large extent, features of our modern corporation and factory system, although there are still many secrets in the possession of individuals who use them for their own advantage, sometimes selling the knowledge of them to several concerns, always under a pledge of secrecy which the

courts would enforce. I do not see how these changes in industrial conditions affect the question under discussion. The reasons which led to the original protection of such secrets against breach of contract or breach of faith one hundred years ago, are sound today. If such protection was fair and reasonable then, it is fair and reasonable now. If it was then in the public interest as leading to the promotion of the useful arts, the same is true today. If such secrets were entitled to recognition in the last century, it was because their existence and support were in harmony with public sentiment. Unless that public sentiment has changed, they are still in harmony with it. I do not believe that it has changed.

82 The law on the subject is the same whether the secret is of large or small importance, whether it is possessed by an individual or a corporation. We should not forget that any one of us in this room, and any workman in any factory in the land, may light upon such a secret. If he does, it will have the protection of the law. It may be used by the one who possesses it, or he may by contract determine the manner and extent of its use. In any case he will have control of it as a reward for his intelligence or forethought in coming into possession of it. He will have encouragement to put it in use, in which case the public will get a benefit from it which they might otherwise never have received.

83 A consideration of possibly more moment is that there is offered to the originator of certain special forms of industrial secrets, or to his assignee, the protection afforded by the grant of letters patent. It may be contended that the opportunity to patent an invention is all the encouragement to the promotion of the useful arts that is required in the public interest, and that there should be no other reward for the origination of a new thought or of a new method or device than that given by a patent. Passing for a moment the point that only a small class of useful ideas are capable of receiving the benefit of letters patent and referring only to things that are patentable, such a view does not seem to me fair or reasonable. Why should a man be forced, against his will, to publish what is in his mind? Ought he not to be allowed to determine for himself what is for his interest? Should he not be free to decide whether he is likely to get an adequate reward, under the patent act, if he does make the publication? If he concludes that such will probably not be the case, should he not be at liberty to use his new idea as a secret in his business, or in some business with which he establishes relations, taking his chances as to the secret being discovered?

84 The whole law of patents implies the right of a man to keep as

a secret that industrial improvement which he has conceived. It is because that right is recognized that patent laws exist. They say in effect: "You, the inventor, have a trade secret which is, among other things, new, useful and the result of invention. You may keep this secret if you can, and so long as it is kept secret you and those claiming under you alone may use it. If your secret is discovered without breach of faith, as may be the case at any moment, you lose it absolutely. Do you not prefer to make a contract under the patent law by the terms of which you are to publish your invention in the best form known to you, and in consideration of that publication secure a right, which you cannot otherwise have, and which shall be enforceable by law, to prevent the use of your new idea by any others without your consent for a limited term, say seventeen years? You will, to be sure, sacrifice the chance you now have of keeping your invention for an indefinite time a secret and therefore in your own control, but in return you get the right to invoke the aid of the law to restrain any use without your consent for a certain period. Which course do you think most for your advantage?"

85 If all trade secrets could be patented, and if the patent law was as satisfactory in substance and in administration as we wish it might be, there can be no question which course would be the most advantageous to the one who possessed the secret. A patent would be enormously more satisfactory than the chance of preserving a trade secret. The latter, at the best, is a most uncertain and insecure property. It may be lost so as to be open for use by any one, in innumerable ways which are not within the scope of the rules of law to which I have referred. It may be disclosed by accident by the one who possesses it, or unintentionally in such a way as to involve no breach of faith by those who know it.

86 As I understand the decisions, even unfairness or want of faith on the part of one who receives knowledge of the secret in confidence, does not make it impossible for him, before he is enjoined by the courts, to disseminate the information so that those who get it from him may use it freely. A person who has notice of the incapacity of his informant to violate confidence, or one who has given no consideration for the information, would be subject to injunction. On the other hand, a *bona fide* purchaser of the secret who had no notice of any beach of confidence or of contract on the part of the one who sold him the information for value, could, I believe, use the information without interference from the courts. He, as a *bona fide* purchaser for value and without notice would have an equity equal to that of the possessor of the secret. Under such circumstances the courts are not likely to interfere.

87 If a disclosure was wrongfully made in trade journals or otherwise, it would be a difficult, almost an impossible task for the one whose rights had been violated to secure redress against the entire public who had read of the secret and who were actually innocent of any breach of faith. Moreover, where there is a trade secret, the fact that it exists is likely to be known throughout the trade, and each competitor has the full right to find the secret for himself, using all information as to its nature and the results from it that he can get from an inspection of the product, from speculation, or in any fair way. I will say nothing as to unfair ways that might be employed and which might be carried out with effect, but so shrewdly as to evade the law. No man would prefer a trade secret to a patent if the only question was one between the chance of keeping his device or method to himself indefinitely without publication, and publication with a reasonable certainty of protection during a limited term. But the issue does not come up in this simple fashion.

88 In the first place, as is shown by the cases I have cited, many trade secrets are not of a patentable character. It may be that the number of these will be reduced as the law develops. Many such should surely be capable of protection in some way. There is no other possible way than through the present rules of law to which I have referred. Most of these unpatentable ideas are of relatively small importance.

89 Of the valuable trade secrets such as new mechanical or chemical processes, some undoubtedly have or once had patentable quality.

90 Should the taking of a patent be the only possible protection for these? I think not.

91 There are many valid reasons why the discoverer of a new industrial process may well determine not merely that it is for his interest to take his chances of keeping it secret rather than to publish it in a patent, but that the latter course might lead to disaster. While it is generally but not always easy to prove an act of infringement of a patent on a product, or a tool or a machine in general use it is often practically impossible to obtain legal proof of the process employed by one who is believed to infringe a process patent. The infringer is very apt to be able to keep his infringement an undiscoverable secret. I am inclined to the belief that a substantial part of the important and valuable trade secrets now in use, most of which are processes, would if patented be used without much if any chance of redress on the part of the patent owner. At any rate, if the one who controls the secret fears that he could not prove infringement of a patent, is it contrary to public policy that he should be allowed to take his chances of

keeping what he has discovered a trade secret rather than run the risk of losing it altogether by publishing it?

92 Again, nothing can be patented unless it involves invention. Pages have been written by way of defining invention. Many of our greatest judges have given all possible thought to the subject. It is still indefinite, however. The judgment of the Patent Office on the point is every day overruled by the courts. No lawyer can advise any confidence in a great number of the cases that come before him.

93 Inasmuch as a trade secret is a man's own, to use or not as he pleases, can it be required that he should absolutely give up his opportunity to utilize his idea for his own benefit, and incidentally for the benefit of the public, in his own factory and under the seal of secrecy, and take a patent which might be declared invalid for want of invention, no matter how useful and meritorious the subject matter might be? In like manner, when one takes a patent, he exposes himself to the danger of having it declared invalid on any of an innumerable number of other grounds which he cannot foresee or guard against. If he prefers to keep what he has a secret, if he can, is there any substantial ground why he should not be allowed to do so?

94 Moreover, admirable and effective as is our patent law, there are involved in its administration many difficulties other than that of proving infringement. In practice it is most cumbersome and expensive. Years are likely to elapse before a test case can be determined, during which infringement becomes general. Under our present court organization, with no single appellate tribunal covering the whole country, a victory for the patentee in the first case does not settle the situation. He may have to sue many infringers in many parts of the land before his rights are generally recognized.

95 Our patent system is probably the best in the world, and it is certainly administered by the courts of great intelligence and high character. The difficulties to which I have referred, and other like difficulties, are inherent in any patent system. Certainly it would require strong considerations of public policy to force an inventor to take what is offered by the patent law as his only form of reward when he may see clearly that the new thing which he has may not stand the strain of patent litigation, but may be profitable to him, and useful to the community if he can keep it for a reasonable time as a trade secret.

96 It is to me somewhat significant that the legislatures of England and America which have many times dealt with the patent law have never directly touched the subject of trade secrets. They seem to have recognized the fairness and justice of the common law rules on

the subject, and that the only course which would commend itself to a sound public sentiment was to make the patent laws so attractive as to induce the owners of patentable trade secrets to publish them in consideration of the patent grant. In this they have to a large extent succeeded. There are an innumerable number of patents, and a comparatively small number of trade secrets. It is only in a few special classes of subject matter that the patent is not a more attractive reward for the new contribution to industrial progress than is the limited protection given by the law to a trade secret. There are few situations in which the secret can be kept at all, even if everyone exercises the utmost possible good faith. It is impossible in the case of a product, whether chemical or mechanical, and more than difficult in the case of tools and machinery. It is only with processes which are practiced in a factory and which are not disclosed by a study of the product that there is any substantial chance of maintaining secrecy. To a far less extent, tools and machines which are not generally distributed have some chance of being kept secret.

97 If a man elects in those few cases not to publish but to take his chances, can there be any real objection to his pursuing that course? It is certainly inconvenient and annoying to some extent. It is a real personal hardship that a workman or engineer who has learned the secret under such conditions that he must respect it, can not utilize it in his subsequent work. It undoubtedly holds back the progress of the useful arts to some extent that the whole world is not free to practice it and to improve upon it. But this, in theory, is equally true as to things that are patented, during the long term of seventeen years in which no improvement on the thing patented can be rightfully used except by the patentee or those claiming under him. It would be true of any monopoly given the inventor or devisor of a new thing as a reward. But the progress of the useful arts is, I believe, enormously promoted by the patent system. I doubt if it is interferred with to any appreciable extent by the requirement of good faith in those who have in confidence become acquainted with trade secrets.

98 On the other hand, I believe that sound business generally and the comparatively few arts in which such secrets are of any importance are definitely promoted by the fact that the law aids in preventing disclosures based upon bad faith.

99 I have referred to the analogy between trade secrets and patent rights, on the one hand, and the privileges of copyright on the other. The analogy is significant as showing the logic of the law, and the basis upon which it has been developed.

100 The copyright which protects a publication of any kind is purely statutory, exactly as is the protection given by letters patent. It is an inducement to publish, that is, to give to the world what might otherwise never be published. As in the case of a patent, it secures to the owner a monopoly for the thing published for a limited term, after which the field is open to everyone. It is distinct recognition of the author's right not to publish unless he chooses.

101 But in addition to the statutory copyright, there is a common law copyright which does not deal with publications at all. This protects the unpublished book, or piece of music, or play, or picture, and even the letters which one writes, against publication or exhibition by others than the person who originated them or secured the lawful control of them as unpublished material. The protection is the same as that in the case of a trade secret. The right of the owner to publish or not, as he pleases, is recognized as absolute. He may make what private use of the unpublished material he chooses. He loses all common law protection if and when he publishes. Up to that time those whom he takes into his confidence must respect his sole and exclusive control of the unpublished matter. They can not publish it nor can they use it without his consent. It is obvious how close this branch of copyright law is to that governing trade secrets.

102 This is only another illustration of an application of the principles for which the courts have contended in the development of the law as to trade secrets. In both cases the authorities are substantially a unit, and their views seems supported by public opinion and consistent with sound business policy.

103 Such are my views as to the ethics of trade secrets. They are those of the courts, and I believe of the public. I recognize that all industrial questions are now under investigation. Much good will comes from a fresh study of them in their relations to modern social, political, and economic conditions. There is no class of men in our land more capable of coming to sound conclusions on such subjects than that represented by the Society which I now have the honor of addressing. There are no men whose influence is greater.

104 The question we have been considering is only one of many upon which the community has had settled views which were reflected in the unanimous findings of the courts. As to some of those questions, it may be that we are on the verge of marked changes of thought which may result in equally great modifications of what have seemed to be sound and permanent industrial and business principles, and in the applications of those principles. The engineers of the United States will surely be on the right side of the discussion of these sub-

jects, and of any political or judicial action which follows those discussions. It may be well in every case to consider the grounds for the doctrine that has prevailed before condemning it altogether. It will always be necessary to determine whether the criticism should not be directed to the applications of the doctrine; that is, to the special cases, rather than to the doctrine itself. In the matter of the trade secret, there may be hardship or even wrong in special cases. If so, let us find out how to deal with the subject so as to retain what is right and to eliminate what is wrong. A modification of the present rules of law may perhaps be essential to that end.

105 The important thing for us to determine is whether or not the prevailing views as exemplified in the decisions of the courts, are not fundamentally sound, based as they purport to be on principles of thought and action that are in harmony with elementary rules of public policy and good morals. If they are right they should be sustained. For myself, and speaking generally, I can not see what fairer or more reasonable views could be advanced in their stead.

DISCUSSION

ETHICS OF TRADE SECRETS

By Frederick P. Fish, Published in this Issue

Henry D. Hibbard Suppose a man enters the employ of another who is conducting a secret business, or rather a business in which are used what are known as trade secrets. He learns these trade secrets and uses them in carrying out his work. . From time to time he introduces new things and processes, ways of doing, etc., and improves the processes used in his employer's work. After a time he leaves the employment in question.

2 Now, what is the proper ethical procedure of both our supposititious man and his late employer? The employer will without question continue to use the improvements unless restrained by patents. Should or should not our man also, if he chooses, use the improvements he has introduced, whether so doing requires or not the use of knowledge he learned while in said employment? ·

Mr. Fish As a matter of law, and, as I think, of ethics, the employee should not use the trade secrets that his employer had when he went to work for him. The probability is that the trade secrets adopted as a result of the work and intelligencce of the employee also belong to the employer, so that the employee should not have any right to disclose or use these after giving up his employment. Such must necessarily have been the contract of service between the employer and the employee. My answer to the last question is, that as a matter of law and also of ethics, the employee should not use or disclose the improvements that he has introduced, if the understanding was that they were to belong to the employer, and that, in any event, he should have no right to disclose or use the trade secrets upon which his improvements were based.

A MECHANICAL ENGINEERING INDEX

By W. W. Bird and A. L. Smith, Published in November Proceedings

Mr. Luther D. Burlingame I have read the paper on "A Mechanical Engineering Index" with much interest and feel that it

shows an appreciation of the needs for such an index as is described, and also an understanding of the ways and means required for supplying such needs.

2 For many years we have been working to adapt to our needs the various indexes required in our drafting and engineering departments at the Brown & Sharpe Co., and among the many forms of indexes which have had attention that for trade catalogues has had its due share.

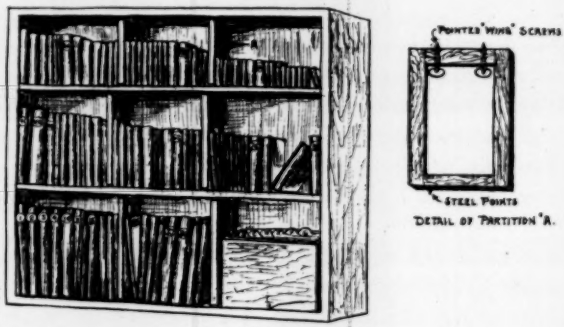

FIG. 1 SHOWING THE DIVISIONS DESCRIBED

3 At first we filed the catalogues in drawers with divisions for groups of four sizes and used a card index for reference, much as described in the paper under discussion. What we now consider a better method is to file the catalogues vertically in cases, as shown in the sketch herewith, the catalogues being arranged in order by sizes, and numbered from 1 up. In starting a new index numbers could be skipped to allow for additions. Even in our case where, when we started this system, we had thousands of catalogues in index, we allowed some spaces. When the size of a new catalogue is such as to bring it between two consecutive numbers, as between 41 and 42, it is numbered 41a, the next one of this size 41b, and so on through the alphabet, thus allowing for at least 26 additions between any two consecutive numbers.[1]

4 In addition to indexing the catalogues under the name of the firm, a general cross index of subjects is made something in the nature of a "topical index." Thus, the sample card "Gear Cutting Machines"

[1]When the catalogues are too thin to put the numbers on the back, they are put on the side where they will readily be seen as the catalogues are handled.

is the second card of a set on this subject, giving the names of the firms, the dates of catalogues and their index numbers.

5 There are many circulars, thin catalogues, photos, and advertising clippings that cannot be satisfactorily filed with the regular catalogues. To provide for such, boxes are used which fit into the catalogue cases and are subdivided alphabetically and with special headings by means of tab cards. These are of a size to take 6″x 9″ leaflets with a generous margin, and anything larger is folded to that size. Any clipping so small as to be in danger of being lost is gummed to a piece of blank paper 6″ x 9″.

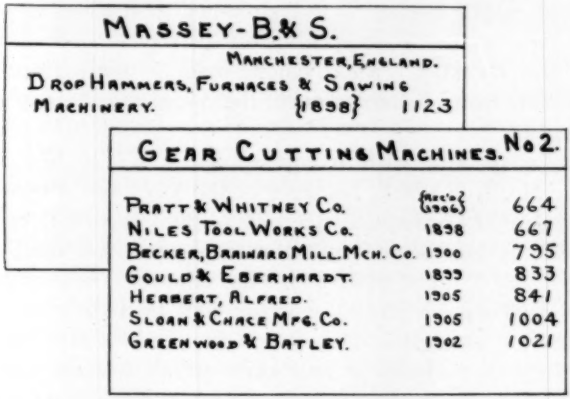
MASSEY-B.& S.
MANCHESTER, ENGLAND.
DROP HAMMERS, FURNACES & SAWING MACHINERY.
{1898} 1123
GEAR CUTTING MACHINES. No 2.
PRATT & WHITNEY CO. {Rec'd 1906} 664
NILES TOOL WORKS CO. 1898 667
BECKER, BRAINARD MILL. MCH. CO. 1900 795
GOULD & EBERHARDT. 1899 833
HERBERT, ALFRED. 1905 841
SLOAN & CHACE MFG. CO. 1905 1004
GREENWOOD & BATLEY. 1902 1021

FIG. 2 INDEX CARDS

6 A charging system is used to know where to locate catalogues that are out. All new catalogues come to and are distributed from a common center, going the rounds of those who should know of their contents before being filed for future reference.

7 Trade literature is indexed by a system independent of the catalogues.

MR. A. B. CLEMENS The index of Messrs. Bird and Smith seems to be generally well adapted to the purpose for which it was intended. The difficulties that present themselves in the preparation of such an index are many, and a scheme that is suitable for an existing set of conditions may be found impractical and cumbersome as the conditions change. The ideal system of indexing must meet constantly changing conditions and should be so flexible that additions of new

subjects and further subdivisions of old subjects can at any time be made without affecting other portions of the system.

2 Herein it seems to me lies a weakness in the system presented. It does not lend itself readily to expansion. This seems to be the greatest objection to all alphabetical systems. Professor Breckenridge says that alphabetical indexes are, or should be a thing of the past. This is, I think, the opinion of most men who have had experience with such indexes. Professor Breckenridge suggests the Dewey decimal system with some changes, and while this is undoubtedly a step in the right direction, it is found wanting in that it provides for only 10 divisions under any one head. The range may readily be extended by using letters of the alphabet instead of figures, thus making provision for as many divisions of any subject as there are letters in the alphabet. Subdivisions may be worked out as in the Dewey system, using either letters or figures, as may in any case seem most desirable.

3 Such a system, with a corresponding set of headings, was devised by Mr. J. J. Clark, Manager of the Textbook Department of the International Correspondence School, and is now in use in that institution. It has been found that it lends itself readily to the indexing of any kind of matter; books, clippings, blue prints, catalogues, or any other material, whether filed in a library or scattered among different departments and buildings, and it may cover apparatus, models, or material of any kind. This is found very advantageous, but the greatest advantage lies in the fact that it provides for a growth from a small index, covering a small amount of material, to an index of large proportions, and also for continued subdivision of any subject as such subdivisions may become desirable.

4 Another point of weakness in the system presented by Messrs. Bird and Smith, is the frequent use of cross references; for instance, suppose that it is desired to find matter relating to Lubrication. We find opposite "See also Bearings, Friction, Lubricators, and Lubrication." After looking through the material indexed directly under Lubrication and failing to find the desired information, we turn to the "See also Bearings," there we find a little more material and here again find "see also Lubrication," "Friction," "Gibbs" and "Hangers." We may then turn to one of these "See also's" and look further, and so on until we have exhausted the various lines of search indicated. It seems to me that such an index fails in the most vital point, the location of desired information in the shortest possible time. This difficulty could no doubt be remedied by using file cards more freely and indexing directly under each head all the matter

relating thereto. This may necessitate the indexing of some matter under a number of different heads, requiring the expenditure of a little more time in the preparation of the index, but saving many times the added cost when searching for needed information.

OUR PRESENT WEIGHTS AND MEASURES AND THE METRIC SYSTEM

By Henry R. Towne, Published in November Proceedings

Mr. J. Sellers Bancroft I have read Mr. Towne's able and very important paper with a great deal of interest.

2 The difficulty in the whole question of the introduction of the Metric system of measurements appears to me to be due to a lack of familiarity with manufacturing conditions, and the want of knowledge as to the investment in organization, drawings, tools, and gages required for the construction of machinery in duplicate.

3 I have been familiar with the Metric system since early in the 60's, a department in the works of William Sellers & Company (with which concern I was associated for more than forty years), having been operated entirely on the Metric system of measurement. The drawings for the original Giffard injectors having all been made on that system it was thought to be an excellent opportunity, as the manufacture was entirely new, to organize the department with the millimeter as the unit of measurement, and to this day I think of injectors, their dimensions, and proportions, in millimeters, but, after my long experience with this system, I am still of the opinion that the inch is a far better unit of measurement, and that for the great manufacturing world there is absolutely nothing to be gained by the transfer from our present system to the Metric system. On the contrary, the expense involved, and the confusion and difficulty of working under two standards for generations would be enormous.

4 To ensure a full consideration of this subject, the dissemination of information as to what the real facts are and what is involved in a change of the unit of measurement of length, I heartily approve of Mr. Towne's suggestion for the appointment of a technical commission for a thorough investigation of the question of standards.

Mr. Oberlin Smith The very interesting and logical paper by Mr. Towne regarding the advantage of the use of the so called Metric

system in this country so thoroughly covers the ground that it is hardly worth while for one who agrees with him to treat the matter at any considerable length.

2 Mr. Towne and many other engineers, including the writer, have argued the question in Washington before Congressional committees and have expressed their views freely in the field of magazine literature, etc. Few of us oppose the Metric system in itself, for it certainly is far more systematic and logical than the mongrel non-system used here and in England. For purposes of calculation, the shifting of a decimal point to the right or left and so rapidly performing multiplication and division, respectively, unquestionably decides its superiority. This advantage is due to its being a *decimal* system, while the various other advantages are attained by the systematic relations of its different units to each other.

3 In performing the act of measuring neither the "Anglo-American," nor the Metric system has any special advantage because such special tools as scale weights, measuring cups, and graduated rules adapted to either system are cheaply obtainable. Naturally the recording of measurements in the decimal system has the advantage, as the fractions are all so much more simply expressed. Were we starting afresh, with new standards established in the dimensions of land and lumber and bar metals and shafting, also in innumerable accurate tools, such as gages, drills, reamers, taps, dies etc., then it is probable that the advantages of the Metric system would tip the balance, so that it would be wise to adopt it universally, both nationally and internationally. As, however, both Great Britain and America, with their colonies, have had the Anglo-American system in use for several centuries, and as enormous quantities of articles standardized under this system are in existence and will remain in existence for a long while to come, especially in the case of land measure, the difficulties of making a change are so tremendous, both as concerns time and money, that any change, even if decidedly for the better, must be very carefully considered. Nor should any such reform be made except upon a comprehensive scale, by the whole civilized world. It should be of such a permanent character that the subject need not again be agitated by any race of beings whose thoughts and habits are akin to ours.

4 To an engineer acquainted with the enormous complexity of our system of tools for industrial production, the idea of changing standards is something appalling in its magnitude, the expense of which, in this country alone, would not be measured in millions of dollars merely, but in billions. Should we make this change to the

Metric system we would still have a very imperfect system of measurement, simply because it would be a decimal system. This seems beautiful to calculators, merely because we multiply and divide by sliding our digits sidewise in relation to unity. Many people have an idea that this beautiful simplicity of calculation arises from some mysterious and sacred quality in the number ten itself. They fail to realize that exactly the same convenience could be obtained were our radix 9 or 11 or any other number of reasonable size. The numbers above mentioned would not be quite as convenient as ten for the practical work of dividing tools or merchandise, because they could not, like it, be parted in the middle, so to speak. Ten, however, can thus be divided but once, and after that the natural, beautiful, and useful principle of *binary division* cannot be carried any further without an annoying series of fractions.

5 Without here specifying details, a little study will show that the binary principle is necessary in almost all kinds of work, from the division of a bushel of walnuts down into pecks and quarts to the graduations on a machinist's scale and to the folding and refolding of a sheet of paper. The only logical numbers for the radix of our numeration are eight and sixteen. These are advocated by many eminent mathematicians. The former is, in the writer's opinion, too small, as more figures would be required than now, upon an average, to express a given number. Sixteen seems to be the ideal number for a base or radix, as being not too large for one to remember easily the six new digits necessary and the new multiplication table which would be required. It is, moreover, much better than ten, aside from its binary feature, as requiring much less paper, ink, and writing in recording numbers. Thus, numbers as high as 255 would be expressed with two digits, and as high as 4095 with three digits.

6 There is no question in the writer's mind but that the whole civilized world will adopt this base, in spite of the enormous difficulties of the change, within a reasonable number of centuries. The time may be shorter than we think, because the reign of common sense in all things seems to be making for the simplification of work in all the walks of life; and this progress seems to be going on in a geometrical ratio.

7 In view of this possible and splendid change in the not too far off future, it would seem well to wait for it before trying to establish an absolutely universal system of weights and measures. Both great reforms could then be made at once (and might not even our villainous English spelling be reformed at the same time), and the world would settle down to a permanent system which would save an enormous

amount of worry and work in dealing with figures and with material things.

8 Whether or not this is only an optimistic dream, let us for the present hold on to our good English inch, not because it is better in itself than any other analogous measure but because it is so well intrenched as to be almost indestructible. Should our base happily be changed to 16, we have already multitudes of standards based on 16ths, 32ds, 64ths and 128ths of the inch. To carry the binary division still further down we would soon reach 1/4096″, which would be expressed in three figures exactly as .001″ is now. So fine a measurement would be about right for most of our mechanical work where the present .001″, commonly marked on our micrometers, is decidedly too large. Should the inch unit be retained indefinitely, as a world's measurement, the enormous volume of industries basing their standards upon it would not be destroyed. The longer measurements, as yards, rods, miles, and all the rest of the hodge-podge could easily have substitutes, with values which were perfect multiples of 16. For these larger measurements but few expensive tools have been made.

9 Should the greater change in question ever be brought about, it would probably be through the medium of some great international commission of mathematicians and engineers, working under the auspices of all the civilized governments of the world for many years. It could be adopted gradually by becoming part of the curriculum of every school, as children could learn it more easily than a new language.

10. As practical Americans and Englishmen, the only thing which it would seem best for us to do now would be to retain the inch and somewhat simplify the other lineal units, keeping in mind as an ideal for the future the beautiful number 16, which can be halved down to unity; which is a perfect square, a perfect 4th power, four times a perfect square and twice a perfect cube. Surface measure would of course be much as at present, with perhaps some simplification. Measures of weight and volume can more easily be simplified and changed than the others just mentioned, as there are pertaining to them very few standard tools; and these are of little value. Should some parts of the Metric system be adopted in this field but comparatively little trouble would occur.

11 There is no question, however, but what an International English and American Commission, as suggested by Mr. Towne, should, if possible, be established, that the whole matter may be worked up with extreme care before any definite legislation is put into effect. Much more careful expert work is required than can be performed in the committee rooms of a Congress or a Parliament.

A PLAN TO PROVIDE A SUPPLY OF SKILLED WORKMEN

By M. W. Alexander, Published in November Supplement

Mr. H. F. J. Porter: It is very necessary for us to understand that the motive for giving shop instruction to our workmen is not by any means philanthropic in its nature. It is on the contrary solely a business one, for the purpose of strengthening our working organization that we may get from it a better and cheaper workmanship.

2 To accomplish these results I think I can show that we must not only educate our employees but *we must try to hold them in our service afterwards* for it is perfectly evident that if after we have educated them they go elsewhere our efforts to improve our working conditions have been futile and should they go to a competitor we have actually spent money to our own business detriment. I think that the General Electric Company has not sufficiently emphasized this point in its curriculum, for although (in paragraph 41) Mr. Alexander states that it encourages its apprentices to remain in its service, still further on (in paragraphs 42 and 43) he shows that nevertheless there is a strong tendency for them to leave, in fact a very large percentage do leave. It seems to me that these boys should all understand that they are in line for advancement for better places than they could hope for elsewhere, and that if they go away they will lose their turn. I fear that Mr. Alexander's wish is father to the thought that those who leave will return, but the probabilities are as great that they will not, nor will it do for him to excuse this defect in the system by saying that they will be benefited by rubbing up against the world. If he has taught them the best way to do things, it ought not to be supposed that they will find any better way outside, while on the contrary they will see many other ways which are worse so that with their lack of experience and at their impressionable age if they do come back they will have learned nothing good and a great deal that is bad.

3 Now, we know that education is a very expensive luxury. This is shown by the appeals for funds made by our educational institutions all over the country to help them carry on their work. So that it is quite possible that a manufacturing enterprise may go into an elaborate system of industrial education and find that the latter would not only fail to accomplish what is desired, but might actually involve the company in financial difficulties by the attendant expense, especially when it is working on the small margin of profit which the close competition of the day makes necessary.

4 I want now to give some evidence which will bear me out in my assertion that manufacturers are not accomplishing what they are striving for by simply establishing in their shops apprenticeship systems or other systems of educating their employees. I shall mention a few concrete instances which have come under my own observation, as examples.

5 In a works in Pittsburg, of which I have some knowledge, there had been a large financial loss for several years, owing to poor business management on the one hand and an inferior class of employees on the other. Under a new business administration improved working conditions were introduced in the factory, with the result that a better class of employees was attracted there. Now, these works were dominated by the same interests which controlled a very much larger works near by, where an expensive apprenticeship system had been instituted and kept running for several years.

6 Under the conditions established by the new management in the smaller works the attraction became so strong that employees from the larger works were drawn there, which brought a protest from the management against taking away the graduates of their apprenticeship system. The opportunities for advancement were so superior in the smaller works that they acted as an allurement which the larger works had provided nothing to offset. In fact, it was the policy of the latter to fill its best positions from outside sources instead of from its own organization. The effect of this policy was to destroy all hope of advancement among its employees and everyone who had any ambition to better himself went elsewhere as soon as he got his equipment. I had previously heard that these works were educating mechanics for other concerns all over the country and I then had the evidence presented to me at first hand. No effort was subsequently made to close the gates at the larger works and the exodus went on as merrily as ever so that the only effect of the protest which had to be heeded was to preclude the smaller works from enjoying its share of the benefit.

7 In a works near Philadelphia, of which I have more recent knowledge, a slightly different condition existed. The works were situated in a beautiful suburban district, the wealthy residents of which did not want a factory, nor workmen's houses located near them, nor did they want any trolley lines in their vicinity. The result was that the workmen in order to reach the works at 7 o'clock in the morning had to arise at 5 o'clock and sometimes stand up in the cars for three or four miles and then walk a mile and a half from the nearest trolley and steam railway, so that they had actually done a half day's work before they started in at the factory.

8 Good mechanics could get work elsewhere which did not entail such inconvenience of access; consequently, it was only an inferior class of workmen who could be persuaded to go there. Now these men had to be educated after they went there in order to perform their work satisfactorily, but it was found that they stayed only long enough to acquire sufficient knowledge to equip them to enter other works of the same kind in the city proper. In fact, it got to be known as a feeder for a large locomotive works there.

9 I happened to be at these works for the first time last Easter Monday. Now Easter in Pennsylvania is a notable festival, the effects of which often last over till the next day, and when I arrived at the works in the morning with the manager, the superintendent greeted us by saying that he thought he had better shut the works down for the day as there were too few men present to run them economically, and that many of those were not in a fit condition to work. There were then 98 men in the organization and 36 per cent were absent.

10 Since that time working conditions have been made more attractive there. Transportation facilities have been secured. Workmen's houses of an inexpensive but adequate character have been made available and a club house has been opened. At the present time, there are 210 men in the organization and last week, the day after Thanksgiving a genuine holiday, only six per cent were absent. Several of the absentees were away by permission and there was no evidence that those present were not fit to do their full duty. In other words, in six months the organization had increased more than 100 per cent and the absentee question was no longer a live issue. I mention this incident to show the effect of a change in management on the character of the organization. It is not necessary now to maintain the system of education previously established. The helpful features of the place are strong enough to bring back not only old hands who had been educated there, but graduates of apprenticeship systems of other works come there as well. These men are good enough mechanics for the work in hand and they stay.

11 Again, take a works in this city with which I am familiar. The proprietor this fall told me that it was very difficult to get good workmen, that the labor market in New York contained only floaters, all the good mechanics going to the nearby manufacturing towns. I told him I thought that if his inducements were strong enough he would have no trouble in getting as good mechanics as he wanted. He asked me to visit the plant, which I did. The manager there told me that he had an average loss from his organization per month of

15 per cent or 180 per cent a year. He said there were 700 men in the organization and that as many had entered and left the works during the summer months alone. Now every one of the workmen who came there had to be educated more or less to do the special work in which the plant was engaged, all of which was being lost to it, its benefit going to others. Changes were at once instituted in the character of management which are now rapidly reducing the percentage of losses.

12 A large and representative works of which you all have knowledge has over 4000 men employed. It has an apprenticeship system which has been described in the magazines as being very advanced and complete and I have no doubt ranks with the system at the Lynn works. My information of conditions there is as recent as last week when one of the officials told me that the percentage of loss of employees is from 8 per cent to 10 per cent per month, or up to 120 per cent per year. This should not be construed to mean that the entire personnel of the working force changes every year, for a very large number remains permanently, but it means that nearly 5000 men, which is more than there are in the whole organization, pass through the works every year, each having received a certain amount, and I know from the character of those works that each would receive a large amount of personal attention, supervision, and education, all of which are extremely costly. Now, if a company, run under good business management should lose a large portion of its plant during a year by being washed away by a stream which flowed by its side it seems to me that a great effort would be made to prevent a recurrence of such a disaster. And there is all the more reason for summary action when the stream of humanity that flows by a works carries away such a large part of the working organization. Recognized authorities on management have emphasized the importance of upholding the integrity and solidarity of the working organization.[1] There is nothing so expensive to a company as constant changes in the personnel of its working force. It seems to me that the weak point in our systems of Industrial Education is in not laying our foundation deep enough.

[1] In my paper No. 1101. Vol. 27, on "The Realization of Ideals in Industrial Engineering," presented at the last annual meeting, I quoted Mr. Andrew Carnegie as saying that: "Should some great catastrophe destroy all of his mills, but spare his organization, which had required many years to perfect, he might be inconvenienced temporarily, but that he could depend upon his organization to reestablish his business. If, however, he should lose his organization, even if his mills were the best in existence and were left intact he would not have time nor strength to rehabilitate himself in the business world."

13 To my mind it is necessary, by the adoption of the simple means included in the term "Industrial Betterment," first to increase the *attractive force* in a works in order to bring to it a better class of men, and second to develop a *cohesive force*, to hold them there. Then you can educate the organization to good and permanent effect. In order to develop these forces you must teach the owners and managers of works the economic value of industrial ethics that they may appreciate the advantages to be derived from fair treatment and comfortable and sanitary surroundings in order that men may be kept contented and in good physical condition for permanent service. In too many factories there are men and women overworked and underpaid and otherwise unfairly treated. Too many factories are dark, cold, unventilated and otherwise unsanitary. All the education in the world that you can give your employees will not bring about in these places the results contemplated. Such conditions should be prevented as well as cured and to bring about improvement in this direction intelligently, it seems to me that we should begin by having our schools and colleges educate our boys, who later may become factory owners and managers, in such a way that they will take into account the human element in business.

"The conscience which recognizes obligation" which Mr. Alexander mentions (in paragraph 12) should be developed in the management as well as in the working organization.

14 The Society for the Promotion of Industrial Education, which our Mr. Higgins has just launched so successfully, held a meeting at Cooper Union, at which one of the speakers referred to a point which your President has brought up, viz: the severe competition of our country with Germany, and asked if it was not a fact that Germany, before she had established her industrial school system, possessed a deep realization of the value of the ethical treatment of her working people and had encouraged them to live a healthy, thrifty, and moral life so as to develop into strong, happy, and contented working men and women.

15 Afterwards she saw to it that they were given sanitary and cheerful working conditions and then, but not till then, did she educate them. When we realize as deeply as Germany the true value of the full and willing service of a man, I think that in the industrial tug of war between that country and ours, we will then and not before be able to pull the marker over to our side.

MR. MILTON P. HIGGINS There is nothing so important to the manufacturer and to the workman himself as the provision for a supply of skilled workmen.

2 The future of American industry is more dependent upon a supply of skilled mechanics than a supply of any other class of men. Engineering colleges have accomplished more than ever was expected, in producing a large number of men for educated mechanical engineers. The engineering graduate is every year more and more of a professional engineer, and less of a skilled mechanic. Still the mechanical engineer must depend upon the machinist for the realization of his plans and ideas.

3 In one Massachusetts town, there are 106 High School graduates in the local engineering college. Each one of these boys went from the ninth grade into the High School with a fixed intent to fit for the engineering college. What about the 106 boys who did not choose to go to college, but stood next to the 106 who were able to take the engineering course? What becomes of this strata of man—material just below the strata from which professional engineers are made. That second strata is more important to our industrial life than any other. These are the boys who ought to learn trades. These are the boys who ought to become skilled workmen. These are the boys who should make the men who can intelligently control the ponderous machine, and guide the tool of precision. What chance have they? The outlook in the ordinary shop and foundry is not bright enough for that grade of boy, because if they go into the ordinary shop or foundry their opportunity of education is cut off.

4 There is hardly a possibility for such a boy to obtain the effective shop skill that he desires, to say nothing of any mental discipline and technical knowledge necessary to his trade. So at present, the boy just below the one who aims to become a professional engineer leaves the ninth grade of school, and drifts from one thing to another, never mastering any trade or business.

5 Is not this state of things deplorable when the positive limitation to American productive industry today is the dearth of skilled workmen? It is of vital importance that effective effort be made to meet this national emergency. It behooves us to hail with great interest every such successful effort as this described by Mr. Alexander at Lynn. I can speak with confidence of this work established by Mr. Alexander, because for years past, I have observed its progress frequently. This gratifying success in training and producing intelligent skilled workmen comes about largely from such facts as these:

It is recognized that industrial education consists of two parts, viz.: skill and schooling—two parts as real and vital as body and mind, two parts of equal importance.

6 At Lynn, they believe that nothing is too good for a boy who is learning a trade—the best tools and machines, the best variety of work, and the best instruction is given the apprentice. Only men who have had experience in training boys for skilled workmen, can conceive of the great possibilities with such boys in the way of making all round skilled workmen in a short time.

7 It is not easy to appreciate what results can be attained in the line of producing shop products of high standard, upon a commercial, profitable basis, by apprentices, under good conditions.

8 It is not every shop that can do this as well as the General Electric Company are doing it, because they are not prepared to establish and maintain a high school as a part of the works, nor is the average shop management prepared to organize and carry on systematic training as it is carried out by Mr. Alexander. With these difficulties in view, I still adhere to the idea of accomplishing these same results in a simpler and surer way—by what I call a *half time school system.*

The public school can and ought to give boys who are learning a trade a high school course of education adapted to their needs and circumstances. So far as text book knowledge and mental discipline are concerned, it is as much the place of the public school to fit boys for the life of a machinist as for any other life. This can be done in a part of the time during the high school period, while the boy is in a training shop similar to the Lynn apprentice shop the other part of the time. The shop training (*i. e.*, the development of shop skill and experience) is the vital part requiring attention in industrial education, and the problem is greatly simplified when attention is concentrated upon this vital part.

9 To do this, it is necessary to have a training shop with the one object of teaching a trade, for example, the machinist's trade. I would first take this trade because it is the foundation of most other trades. The machinist's trade is by far the broadest and most far reaching of all mechanical trades. It is the foundation of all manufacturing, and all mechanical engineering. The difference between the machinist and the mechanical engineer is not a difference of kind, but a difference of degree. We can make no greater mistake than to think that automatic machinery, division of labor, etc., in any way eliminates our need of competent, all round, skilled machinists.

10 Our machinists require a different training and more mental

discipline than the machinists of former time, but he fills a more important place than formerly, and the dearth of this high grade machinist is the most positive limit to the advancement of productive mechanical industry in America. The machinist we ought to produce by our training shops coöperating with the public school, is the man who is to work at the bench and the lathe, and every other spot in the whole realm of industrial works, where intelligent skill counts. The skill of such a machinist should not be confined to a single department of work. He can well afford to be a pattern maker, a molder, and a draughtsman, as well as an expert workman in the machine shop where rapid production and work of the finest precision is required. It has been demonstrated within the past thirty-five years that it is quite possible to produce skilled workmen in a three or four years' course, and at the same time secure a considerable mental discipline. The mental discipline begun upon school book work in the schoolroom continues in the most gratifying way when the boy drops the school book for the work with tools.

11 The thinking workman who studies under right conditions is likely to strengthen his mental capacity by turning to shop work better than is possible in any other way. The half time combination is most effective. It is a great mistake to train large numbers of men for mechanical industry from the top downward. There is always disappointment and failure but if we can begin with the skill of the machinist as a basis, made as broad and as varied as possible but with absolute practical thoroughness in personal skill supplemented with considerable mental descipline, there is no limit to the future advancement of such skilled workmen. This great possibility becomes assured when the training consists of equal portions of school book discipline, and *shop* experience, both halves of the education based upon shop work, and shop experience.

12 In order to do this most effectively, we must enlist a grade of boy who has a love and respect for mechanical work, a boy who can take pride in good work and intelligent skill, a boy who is not ashamed of his calling and vocation, a boy who is not ashamed of overalls, and is proud of clean hands only after a hard, dirty, difficult job has been completed. There has been a sickly, weak shrinking from healthful pride in skillful work. In some cases this weakness has been shown by calling machine shop work "machine laboratory exercises," and by calling the foundry the "molding laboratory." There is no element in the life of a nation that more truly determines its rank in the scale of civilization than the mechanical skill of its artisans. Mechanical skill is something to be proud of—not to be ashamed of—for skill is

the counterpart of knowledge, and these two combined constitute the creative power of a people. Even with the great advantages of America, with her abundance of room and material, and with her organizing and engineering ability, we are not sure of a leading place among the nations, unless we secure more and better skilled mechanics. Our greatest danger lies in the lack of highly trained native mechanical skill. At present, there is an enormous gulf between the professional engineer and the unskilled or highly specialized operative.

13 Our only remedy is organized industrial education, based upon the recognition that practical mechanical skill is the true basis for all this effort. Knowledge and skill must be organically combined in the same man to meet the needs of our industries, but the greatest of these is skill. More knowledge without skill will simply add to the supply of good for nothing people, and skill with insufficient knowledge cannot meet these latter-day demands in our shops and factories.

14 Why have we made so little progress in meeting the needs of industrial education when there is such a prevailing interest in it?

15 It is this: Almost all effort has been directed to means of adding more knowledge, when almost nothing has been done to secure mechanical skill for the boy who is not very deficient in his schooling. There are thousands of evening schools and extension schools for the skilled workman who needs them, but none that fully meets the needs of an intelligent boy who requires thorough practical mechanical skill and experience.

THE EVOLUTION OF GAS POWER

By F. E. Junge, Published in November Proceedings

Mr. R. E. Mathot After the very elaborate papers that have been read regarding the question of growing interest of the application of gas engines and producers, I think it will not be useless to lay before you some figures that will illustrate the present status of this matter on the European continent, from where, I believe, I am the only member attending this meeting.

2 In addition to the very interesting papers presented by Mr. Junge and Mr. Bibbins, and discussed by such authorities as Professor Lucke and Professor Fernald, I should like to present in a few words the leading principles that are now ruling the European construction of large engines and the results that have been derived from the application of these principles.

3 The iron and steel industry is the one which has mainly caused the rapid growth of large gas engines, and Germany has kept at the head of the development, owing to the importance of its metallurgical industries. In that country, it has been recently stated that among 50 smelting works actually at work, 42 are already using, or have ordered, large engines for dealing with the gas generated in the blast furnaces, or smelting ovens, or coke ovens. This represents 350 units that give an aggregate output of about 400,000 horse power, the largest of these plants being 35,000 horse power, while there are fifteen works using plants of 10,000 to 12,000 horse power. In some of them provision is made to work with producers only in case of need, to keep the plants at work.

4 In collieries and coke oven works, the competition by internal combustion engines against steam engines is difficult on account of the great number of old ovens from which the available heat can only be used in firing steam boilers. In these installations, however, the number of engines at work or in contemplation amounts to twenty or twenty-five, aggregating a total output of 35,000 to 40,000 horse power. Almost all of the engines used in both smelting works and collieries are of the double acting form, some of the two-cycle and some of the four-cycle type, the latter being, of course, the more largely applied on account of their higher efficiency.

5 The increasing favor which large gas engines have met in metallurgical works will be easily realized if you bear in mind the following figures:

An ordinary blast furnace of a daily output (24 hours) of 100 tons of pig-iron liberates about 315,000 cubic feet of gas which is available for motive power and is of an average heat value of 110 B. t. u. This volume of gas generates, with steam plants, about 2500 horse power while it gives with gas engines 4200 horse power, or a difference of 1700 horse power; this is about 70 per cent more power in favor of the gas engine.

6 Such figures, of course, may not be expected unless the plants are provided with modern improved features among which the most important is means for cleaning the gas, which has, in recent times, been the object of the greatest attention on the part of manufacturers of large gas engines as well as on the part of the users themselves.

7 To get rid of the general impurities that the gas contains, such as dust, tar, and chemicals, which would be detrimental to the good working of the engines, as well as in view of reducing the temperature of the gas before delivery to the cylinders, thorough cleaning, scrubbing, and cooling are necessary.

8 These operations are effected by means of fans, rotary washers, or the like, that involve a water consumption ranging from 0.25 to 0.40 gallon per 100,000 cubic feet of gas. The content of dust can by this process be reduced from 0.3 to 0.2 of a grain.

9 The power required for operating the fans and the washers, depending on the system used as well as the amount of impurities to deal with, ranges from 1.5 to 4 horse power per 100,000 cubic feet of gas, that is, about 3 per cent of the power generated from the gas. With respect to the engines themselves, the cooling water required per hour per brake horse power for pistons and piston pins is from two to three gallons, and for cylinder jacket, etc., from seven to ten gallons. Lubrication in a good engine can be effected with one to 1½ grams of oil per brake horse power hour.

10 In Europe, if within the short period of ten years we have succeeded in installing about 750,000 horse power of internal combustion engines, this is chiefly due to the application of successful methods and principles derived as much from theoretical knowledge as from practical hints afforded by a wide field of experience. Our makers have also been more stimulated by keen competition and the necessity of dealing with more expensive fuels than those of America.

11 In view of meeting as closely as possible one of the unquestionable advantages of the steam engine, with which we have to compete, we aim to build our gas engines with such dimensions that they afford a large margin of power and despite the possibility of reaching in our best constructions the very high mean effective pressures of 90 and 95 pounds per square inch, we rate what may be called the constant working power on a pressure of about seventy-five pounds.

12 With respect to the economy with which the American makers will before long have to compete, it may be stated that nowadays our good four cycle makers reach the thermal efficiency of 30 per cent as an average, relating to the effective horse power. This corresponds to about one brake horse power hour with 8500 B.t.u., which is realized in small single acting engines, as well as in large double acting engines, when working at normal load.

13 About this, let me observe that I have heard of certain American inventors who claim to reach much higher efficiencies with their plants. Tests made recently on small producers purport to show for the complete plants, including generator and engine, 36 to 40 per cent thermal efficiency, after a trial of—two hours! Others state that their producer has 100 per cent efficiency, and still others would convert nitrogen into available power! I know that from both the

industrial and commercial points of view, American conditions are rather different from those in Europe, but I can hardly believe that the differences extend to the nature of your nitrogen, while ours on the old continent has remained obstinately inconvertible. Surely the question of gas power is interesting enough of itself, without having to advocate it in sweeping assertions that are liable to be more detrimental to the good fame of this motive power than modest and unquestionable truth. In French we would call this "faire la mariée trop belle;" in other words, one must never exaggerate the beauty and good qualities of a fiancée because it might frighten her future husband!

14 Now, allow me to select some results of tests made by some of our leading authorities, and some taken from 200 trials that I have been called to make myself, either as an independent consulting engineer or as a referee to the courts.

a Trial of ten hours with prony brake on a 40 brake horse power suction producer and single acting engine of the Maschinenfabrik Winterthur=

Consumption per brake horse power at full load, 0.7 pounds
Consumption per brake horse power at half load, 0.94 pounds
of anthracite coal of 13,850 B.t.u., including ashes and moisture.

b On a similar engine I had already found with illuminating gas a consumption per brake horse power hour at 4/5 load of 17.6 cubic feet of gas, referred to 0° C. and atmospheric pressure, of a heat value of 545 B.t.u. (lower value).

c Test made by Professor Schröter on a Güldner engine and producer; piston bore 250.6 mm. × stroke 400.3 mm.

TEST WITH ILLUMINATING GAS

Load Ratio	R.p.m.	M.e.p. kg. per. sq. cm.	Load i.h.p.	Heat value cal. per cu. meter	Consumption per hour per i. h. p. ref. to 0° C.; 760 mm. bar		Thermal ind. efficiency per cent
½	213.9	4.48	21.	4420	0.3975	0.376	33.9
¾	212.8	6.71	31.3	4410	0.347	0.328	38.8
full	214.5	8.06	37.7	4430	0.3435	0.327	39.
full	210.7	7.76	35.9	4440	0.3145	0.298	42.7

WITH SUCTION FUEL GAS FROM ANTHRACITE FUEL

Load	Rev.	M.e.p. kg.	M.e.p. lbs.	I.h.p.	Heat value cal. per kg.	Heat value B.t.u. per cu.ft.	Gross con. per B.h.p. hour. kg.	Gross con. per B.h.p. hour. lbs.	Thermal eff. ind.
Full	210	7.6	108	34.9	7780	13.878	0.336	0.739	28.5

TESTS WITH DIFFERENT FUELS ON NURNBERG SINGLE-ACTING ENGINES

	No. 1	No. 2	No. 3
Plant			
Fuel	anthracite	coke	illum. gas
Working load; h.p.	107.4	110	152.8
Consumption per indicated h.p. hr. in engine.	0.78 lbs.	0.93 lbs.	15.7 c.ft.
Heat consumed per i.h.p. hour in the producer suction, B.t.u.	10,850	10,840	—
	80%	75%	—
Thermal efficiency of producer, heat consumption in the engine per B.h.p. hr. B.t.u.	6750	6300	6200
	80%	80%	78%
Mechanical efficiency of engine. Thermal efficiency of the plant, relating to the i.h.p.	36.3%	38.3%	36.6%

Owner's location of the plants:
No. 1 Royal Foundry of Würthemburg (Wasserflingen)
No. 2 Imperial Post Office at Hamburg
No. 3 Municipal Electric Station of Greifoland

15 It should be taken into consideration that the above figures show low mechanical efficiencies because they relate to engines provided with very heavy fly-wheels for extreme regularity of rotation.

16 Regarding the consumption of large double acting engines, accurate figures are unfortunately rather seldom obtainable, those engines dealing with such large quantities of gas, that gas holders of sufficient capacity are rarely available for a reliable test. I may mention, however, a trial witnessed contradictorily by the engineers of both makers and users on a double acting four cycle engine of 600 horse power supplied by Ehrhardt & Sehmer, one year ago, to the Königlische Berginspection at Heinitz Saarbruck, Germany. After four months of constant work and without previous cleaning, this engine was tested with coke oven gas ranging from 350 to 370 B.t.u., and showed an economy of 8100 B.t.u., per brake horse power hour. The mechanical efficiency recorded, with the power under consideration, was 83 per cent. The engine was a new one and was tested under normal load at 150 revolutions per minute. The principle dimensions are: cylinder bore, 620 mm.; piston stroke, 750 mm.; diameter of rods, 170 mm. The load reached 520 kilowatts with a three-phase dynamo mounted on the crank-shaft of the engine. It will be seen that even for the normal load, the above figures show a thermal efficiency of about 31 per cent on the basis of brake horse power and 37.5 for the indicated horse power.

17 High efficiencies, smooth running and reliable working are all obtained, thanks to the following principles that are now applied by almost all European makers and govern their construction. The compression has been raised to 160 and even to 190 pounds in order to obtain reliable ignition of the very weak and lean mixtures used for purposes of economy.

18 High compression involves high temperature and we have therefore to design the combustion chamber to allow even cooling and free expansion of the cylinder head. We aim also to design the combustion chamber of such a shape that it affords the maximum volume with the minimum cooling surface and facilitates high velocity of flame propagation in the explosive mixture as well as thorough combustion without the sharp explosions which are of such detrimental effect in the old type of hit-and-miss engine now completely abandoned by our representative makers. In fact, whatever the quality or richness of the gas used, in spite of high compression, we aim not to reach initial explosive pressures above 330 to 360 pounds. This causes our engines to run smoothly, without the knocking or pounding due to early sharp explosions.

19 Governing is always effected by varying the mixture admitted at each cycle, whether by varying the quantity at constant ratio, or by varying the ratio of gas in a constant quantity of mixture or even by combining both processes. The first method causes, of course, variable compression and, as a consequence, some loss of power due to partial vacuum in the cylinder at low loads, but in spite of this defect its principal advantage is to give the highest efficiency at every load because it insures always a good combustion of the mixture exploding in due time.

22 The second method, although being apparently less economical, holds certain mechanical advantages that I shall remind you of later on.

23 The third method, involving a combination of both systems of variable quantity and variable quality, is claimed by its few advocates to embody the leading advantages of the two former methods, without having their weak points. But the combined system leads to the use of somewhat complicated mechanical arrangements and its successful operation might therefore be questionable. As a matter of fact the most rational course seems to consist in the selection of that one of the first two methods which suits better the character of the work the engine has to deal with.

25 In the case of high-speed engines supposed to run at a nearly constant number of revolutions, as for driving electric alternators, spinning mills and the like, the inertia of the moving parts, such as

the piston, the connecting rod, etc., becomes one important factor of smooth working. The moving masses should therefore be kept at a constant speed and the system of governing by variable mixture should consequently be preferred because it gives constant compression due to the admission of a constant volume.

26 In the case of slow-speed engines, such as are used for driving blowing plants, pumps, rolling mills, etc., which allow variations in the number of revolutions to the extent sometimes of 50 per cent, the system of governing by variable quantity with constant quality of mixture will answer the purpose, despite the variation of the compression.

27 All large continental engines are made of the double-acting horizontal type, and although of different detail arrangement, the Oechelhäuser and the Dingler types give a power impulse for each half revolution of the corresponding crank. The general scheme of the automatic cut-off steam engine with valves located at both ends of the cylinder has been adopted in our gas engines as a principle. The inlet valves at the top and exhaust valves at the bottom meet both constructional and working requirements in every respect. With regard to this, the engines of the Allis-Chalmers and the Westinghouse Companies in this country are quite up to date. The question whether their side crank is better than our center crank will be solved by future experience, though, nowadays, it answers better the American conditions regarding simplicity and facility of erection, which are required on account of lack of training of your young engineers.

28 I rather agree that our European engines are too complicated and I am quite confident that when Americans have let us pay for the experience they will before long design large engines that will be much more simple and reliable, thanks to their remarkable faculty of adaptation and their well-known ingenuity. Regarding simplicity, I trust that mechanics will make a considerable step forward when the modern large gas engine has been somewhat Americanized.

PROF. CHARLES E. LUCKE Mr. Junge's paper has for its subject a rather broad consideration of steam versus gas for power. By gas I mean not necessarily gas fuel, but a perfect gas as a working medium behind the piston distinguished from vapors. He has avoided specifically comparisons of different makes of gas engines, and I rather hope in the discussion of this paper that this topic will not be brought up. Any one, on reading this paper, would be apt to get a high opinion of

gas engines for power generation, and, I think, too high an opinion. Gas power, to be worthy of consideration by power plant engineers must be considered in large installations by engines of large size, and should not be discussed for small sizes at all. Large gas engines have peculiarities and troubles not possessed by small engines, and comparison of steam engines and gas engines becomes rather more difficult in the larger sizes than in the smaller ones. I wish, therefore, to examine this question of gas versus steam power, raised by Mr. Junge, and in the light of my presentation to point out a criticism of this paper and perhaps venture on a prediction.

2 I will divide the subject into headings for the examination of the problem:

a "The theoretical possibilities of a perfect gas used in various cycles versus steam used in its best cycles as a method of transforming heat into work." Such examinations on mathematical and thermo-dynamic grounds have been made many times, and they have always proved the superiority of the perfect gas cycle over any steam cycles that can be devised. Therefore, on this point I think I may say without fear of contradiction that the perfect gas cycle is better, and a more efficient means of transforming heat into work than any vapor cycle in which the latent heat necessarily rejected is so high, or in which the difference between total heats at high and low pressures is so small. This would seem to give the gas engine a superior position, and it is along these lines that most of the discussions in print on the superiority of the gas engine are based.

b "The mechanism for carrying out the cycle in a practical machine." On this point I can easily imagine an endless discussion. There are, however, one or two considerations that seem to me more prominent than others, and more important at this time because not generally recognized. The gas engine, in its modern form, that is to say, the form in which it appears in the large sizes, has been through a process of development of only about ten years. We have today large gas engines that will run. Ten years ago we did not. We have not today, however, a specially designed gas engine for each particular set of circumstances under which gas engines have to work. Builders of gas engines have, therefore, taken this single gas engine that would run under certain conditions, not

always clearly defined, and have sold it to perform any kind of work under any other conditions, equally indefinite and the engine has frequently failed as a result. We are today just beginning to recognize the importance of adapting the gas engine mechanism to circumstances and conditions, and are still discovering what conditions affect its operation and what do not. When all of these conditions affecting the operation have been discovered and engineers shall have been educated to use this knowledge in designing proper mechanism, then and then only, will we have special gas engines that can fairly compete with steam engines. The steam engine advocates are very apt to criticise the gas engine advocates and the gas engine advocates are apt to be too sure of the results of the gas engine. This situation is directly a result of either ignorance of the importance of operating conditions and peculiarities of design or a deliberate ignoring of this knowledge, which can only be attained by costly experiments, too costly by far to be ignored.

c "The availability of the fuel." In the early days only gas fuel was burned; later on, vapors of the oils; still later, by-products, such as coke oven gas; and lastly, but most important, gas made from coal in producers. It may be fairly said, therefore, that in the question of the availability of fuel, the steam engine has no position of superiority over the gas engine with the bare possibility of the caking bituminous coal in producers as the one exception.

d "Adaptability of the engine to the work it must do."

e "The skill or cost of the operating labor."

f "The first cost of the machine or plant."

g "Cost of maintenance and repairs."

Several other items of a similar nature can be added to this list of points of view from which the comparisons may be made, but all of them hinge upon the one question of "the design of the mechanism of the gas engine" to enable it to do a special service under all conditions imposed. If it should appear that the mechanism can be made as reliable, as cheap, as easily maintained, as adaptable to the work, etc., in the gas engine as in the steam engine, the gas engine would undoubtedly have a superior place. Unfortunately, this has not yet been proved, and the importance of it is not even recognized by some

of the gas engine builders. The steam engine has been through such a process of development for many, many years, and it is not yet finished. Ever since the time of James Watt, we as mechanical engineers, have been designing steam engines and are still designing them—every day a different one. In other words, we have found it necessary to especially adapt each particular steam engine to the kind of service it has to perform, and to the conditions under which it must work. How different the engines of the locomotive from those of the steam ship, and how different these from the engines of a large central power station. How different are small steam pumps from the large steam pumps, and a hoisting from a pumping engine. How different the high speed steam engine from the slow speed engine; the steam engine using low pressure from that using high pressure steam. We have today no gas engine specially adapted to pumping water; no gas engine fitted for driving ships; no gas engine generally recognized as the one for close regulation; no gas engine specially adapted for mill work, as distinguished from electric generation; no gas engine built specially for long life; no gas engine for power purposes especially distinguished for its small space per horse power, nor one adapted to producer gas as distinguished from blast furnace gas, or to dirty gas as distinguished from clean gas. In short, we have not only not yet designed special gas engines for special conditions, but are only now beginning to realize the necessity for so doing. The failure to recognize the necessity for so doing is the cause of much loss of money and much loss of prestige of the gas engine in the power plant world. I know of only one company building large gas engines, out of a possible list of a dozen or more, that has made any money; practically all of the others have lost money in the business. I know of a great many gas power plants and gas engines that have been rejected for failure to fulfill contract requirements and which have come into the courts for public airing. This loss of money and these failures, together with loss of prestige, and by loss of prestige, business, which is its consequence, are due solely to one thing, and that is ignorance of the limitations of the gas engine mechanism. The builder of the gas engine did not know how to make it particularly

adapted to the work. His knowledge was, in many instances, derived from a few experiments in his shops, or, perchance, from drawings and information obtained from Europe, the home of the gas engine. At this stage he was probably approached by a purchaser, who had read in the papers of the wonderful performance of the gas engine, the machine that could produce a horse power hour on a pound of coal of any kind, any time and all the time. It was with such an idea as this that the prospective purchaser approached the sales department. The builder, having spent so much money on experimenting, trying to get his machine to run and having finally succeeded in making it run, was faced with the demands of the purchaser for a guarantee of 10,000 B. t. u. per h. p. hr. He may not ever have been able to get as low as 15,000; he may not ever have tested his engine at all because of the cost of large gas meters. He may have been dependent upon the same published reports himself, and in his anxiety to get back his money he gave in to the demands of the purchaser. The engine failed, doing much harm to his business besides the immediate loss of money.

3 Now the point I am making is not that gas engines are going to fail and continue to fail, but that these contracts were made on insufficient information on the part of the builder and unfair demands on the part of the purchaser, who, knowing nothing of the subject, allowed himself to be controlled by the public press. The purchaser did not know what was fair to demand, except in accordance with what he had read, much of which was false. The builder, either through lack of time, lack of sufficient capital to experiment properly, or indifference, or lack of able designers, or refusal to take the advice of good engineers, did not know what his engine could do, or did not care. When the public shall have been educated to know what it is fair to demand of the gas engine and to recognize what a gas engine can do, and when at the same time, the builders of gas engines shall have recognized the importance of employing the best talent available to design their engines to meet special conditions and shall take the advice of these experts as to the importance of recognizing limiting conditions, then will the gas engine take its place properly beside the steam engine, and not before.

4 Mr. Junge, in his paper, scarcely mentions this point of view, which seems to be so vital to the question. He mentions some high thermal efficiencies, I believe impossibly high ones, but these are of

absolutely no use in an engine when at times and under certain circumstances that engine will not run. To the public purchasing gas engines or any other sort of engines for power purposes, I appeal:

a To recognize that the gas engine is, at present, a factor to be considered in every power proposition, and that it is not to be ignored in favor of any steam turbine, steam engine, water power, or other system because, perchance, it is not so familiar;

b To recognize that the gas engine cannot do everything, especially when it is in the one-design form, and that what it can do should best be known to its builders and not to the writers of some magazine article.

c To keep the gas engine builder informed of your special requirements, and invite bids on every power proposition, whether it seems likely they can meet it or not, and in issuing this invitation meet the builder halfway by not imposing utterly ridiculous conditions.

5 To the builders of gas engines I make an appeal as earnest as the one I make to the purchasers of this class of machine:

a Employ the best men on general power plant practice that your money can secure, and consider that man most valuable who, with the above information, also knows the peculiarities of your engine and that of your competitor, with the limitations of both.

b Seek to fill the special needs of purchasers without forcing on the public an engine that any good and competent engineer can plainly see is not adapted to the work.

c Properly experiment for the purpose of determining what modifications of design and detail must be made to meet special service conditions, and when once determined execute them.

d Coöperate with purchasers of gas engines or power plants of any sort by exchanging freely all information on the requirements and performance, and give up at once the hermit like attitude of isolation and secrecy heretofore so common.

MR. R. H. FERNALD I desire to express my appreciation of the complete and interesting paper presented by Mr. Junge, and I can but commend the paper to the careful consideration of the Society. Inasmuch as Mr. Junge has referred to my paper of a year ago on

the "Results of the Preliminary Producer Gas Tests of the United States Geological Survey Coal Testing Plant at St. Louis," I desire to take this occasion to submit in a very concise form certain summaries that may be of more or less value to those directly interested in the manufacture and operation of producer plants.

2 The figures given below could not be presented a year ago for the reason that the data upon which they are based had not then appeared in Government print.

SUMMARY OF FUELS TESTED BY THE GAS PRODUCER DIVISION, UNITED STATES GEOLOGICAL SURVEY FUEL TESTING PLANT, ST. LOUIS, MO., DURING THE YEAR 1905

	Number from each State	
BITUMINOUS COALS TESTED		
Brazil	1	
Illinois	16	
Indiana	7	
Kansas	1	
Kentucky	4	
Ohio	7	
Pennsylvania	7	
Virginia	4	
West Virginia	5	
Wyoming	2	
	—	54
LIGNITES TESTED		
California	1	
North Dakota	3	
	—	4
MISCELLANEOUS		
California lignite and cinders	1	
Coke breeze	1	
	—	2
DUPLICATE TESTS		
California lignite and cinders	1	
Illinois coal	1	
Indiana coal	1	
Pennsylvania coal	1	
	—	4
		—
Total tests made		64
Average B.t.u. per pound of coal as fired	12,500.	
Average B.t.u. per pound of lignite as fired	7,526.	
Average B.t.u. per pound of dry coal	13,420.	
Average B.t.u. per pound of dry lignite	10,870.	

Average B.t.u. per cubic foot of gas from coal	151.
Average B.t.u. per cubic foot of gas from lignite	161.
Average cubic feet of gas per pound of coal as fired	59.8
Average cubic feet of gas per pound of lignite as fired	29.1
Average cubic feet of gas per pound of dry coal	64.4
Average cubic feet of gas per pound of dry lignite	40.9
Average pounds of coal as fired per square foot of fuel bed area	8.0
Average pounds of lignite as fired per square foot of fuel bed area	14.5
Average pounds of dry coal per square foot of fuel bed area	7.4
Average pounds of dry lignite per square foot of fuel bed area	10.1
Average[1] equivalent pounds coal as fired per e.h.p. developed	1.74
Average equivalent pounds lignite as fired per e.h.p. developed	2.94
Average[1] equivalent pounds dry coal per e.h.p. developed	1.56
Average equivalent pounds dry lignite per e.h.p. developed	2.04
Ratio of total coal per e.h.p. (under boiler) to total coal per e.h.p. (in producer) equals	2.7
Ratio of total lignite per e.h.p. (under boiler) to total lignite per e.h.p. (in producer) equals	2.6
Pounds of mixture of tar, water, soot, etc., delivered by tar extractor per ton of coal	385.
Pounds of mixture of tar, water, soot, etc., delivered by tar extractor per ton of lignite	175.
Average sulphur in coals tested	2.55 per cent
Average sulphur in lignites tested	2.00 per cent

AVERAGE OF GAS ANALYSES	From Coal	From Lignite
Carbon dioxid (CO_2)	9.5	9.1
Oxygen (O_2)	0.0	0.0
[2]Ethylene (C_2H_4)	0.0	0.0
Carbon monoxid (CO)	19.2	22.6
Hydrogen (H_2)	12.4	14.6
Methane (CH_4)	3.1	3.0
Nitrogen (N_2)	55.8	50.7
	100.0	100.0

[1]This includes all coal charged to producer and coal for auxiliary boiler.

[2]Not separated from methane (CH_4) in this series of tests.

3 In presenting the accompanying charts too much emphasis cannot be given to the fact that the tests from which these curves were deduced have been subjected to absolutely no refinements. With the possible exception of two or three coals, one test only has been made on each fuel, and the result of each test has, to a great extent, depended upon the ability of the producer operator to "catch on" to the methods of handling a given coal within the eight or ten hours allowed preliminary to the official test.

4 To illustrate, tests Nos. 71 to 74 inclusive, taken in consecutive order, were upon coals from Pennsylvania, North Dakota, Ohio, and Virginia.

It should also be borne in mind that all the tests have been made on one type and in one size of producer—a type designed primarily for anthracite coal—and that it has been imperative that the test be made and the required power generated without regard to the proper relations between the gas producing qualities of the coal and the fuel bed area.

5 The restrictions have been such that the tests have been conducted on the basis of steady load on the engine (235 brake horse power) and not on the basis of maximum power producing quality of the coal.

6 In spite of those restricted conditions, the general conclusions derived from tests upon fifty odd coals made during 1905 are regarded as sufficiently significant for presentation at this time, although subject to modification in the light of later investigations. They are accordingly indicated in the following diagrams:

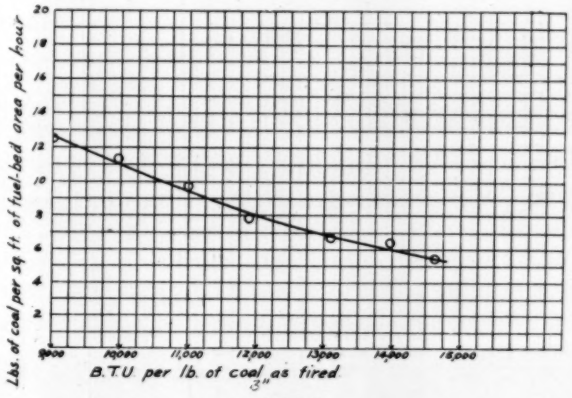

FIG. 1

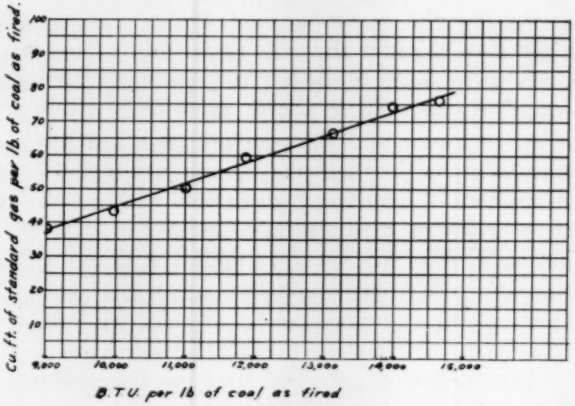

FIG. 2

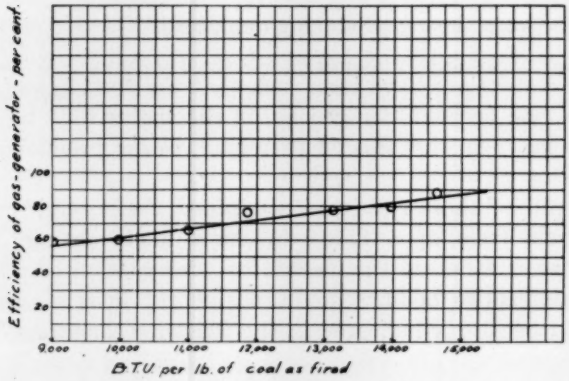

FIG. 3

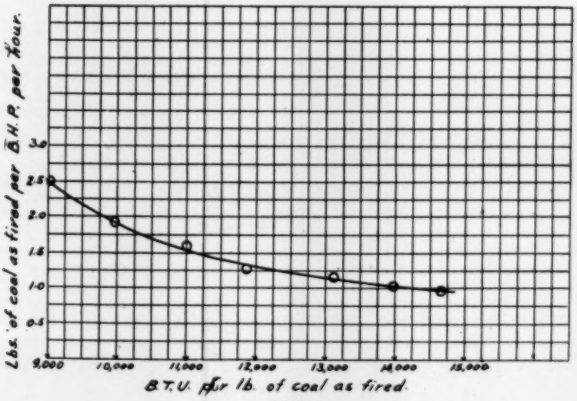

FIG. 4

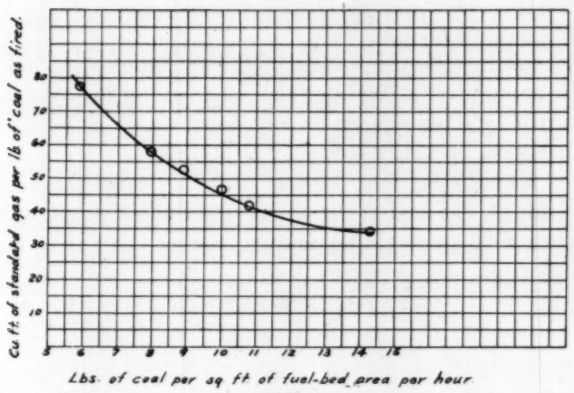

FIG. 5

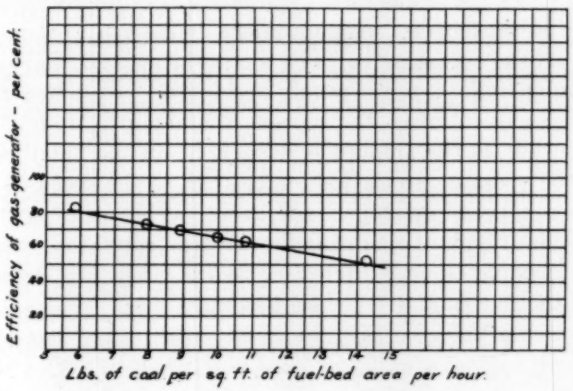

FIG. 6

TEST OF A PLUNGER ELEVATOR PLANT

By Mr. A. J. Herschmann, Published in November Proceedings

Mr. Thomas E. Brown. Mr. Herschmann's paper is very valuable as it applies to a type of elevator which is the subject of much speculation, and has been accepted entirely on the statements of the various makers, and has never before been tested by disinterested engineers.

2 The boiler tests give results seemingly lower than might have been expected.

The day's run of the compound pump resulted in 131.74 car miles at a cost of 7000 pounds of coal.

The day's run of the flywheel pump resulted in 127.63 car miles at a cost of 4400 pounds of coal.

3 This raised in the proportion of the car mileage = 4540 pounds against the compound's 7000 pounds, or a saving in favor of the flywheel pump of 2460 pounds, or 1.1 long tons, which, at $3.40, amounts to $3.74 per day, or $1122 per year of 300 days.

4 When we consider that the cost of the flywheel engine is usually more than double the cost of the compound duplex pump, it is a question whether with so small an annual saving the extra cost of the higher class apparatus is warranted.

5 The automatic valve mentioned in paragraph five, as saving 5 per cent, and which is shown and marked "check valve" in Fig. 7 is a device commonly used with all types of non-circulating hydraulic elevators, and has its counterpart in the circulating type in the "relief valve" in the water chest.

6 This check valve has for its primary object, in all types of elevators, the prevention of a vacuum in the cylinder during up motion stops, should the operating valve be too rapidly closed, and any economy resulting from its use is purely accidental. Any water sucked through this valve during the process of making an up motion stop is a saving, but as the amount is dependent on the handling of the valve by the operator, to the load in the car, to the speed of the car, and to the number of up stops made, as well as how they are made by the particular attendant operating the elevator, conditions continually changing, it would be very interesting to know how Mr. Herschmann arrives at the flat rate of 5 per cent saving.

7 The writer has used this device for many years, but has never claimed for it any substantial or fixed percentage of saving.

Referring to Fig. 7, it will be evident that the back pressure used to operate the check valve is discharged into an open suction tank and is, therefore, lost. Had the auxiliary discharge tank been connected directly to the suction of the pump, producing a suction head, an absolute saving proportional to the suction head could have been attained.

8 The writer is informed that the back pressure is 25 pounds, and if this is the case the saving, were it used as suction head, would be be $25 : 180 = 13.9$ per cent.

9 The introduction of an automatic check valve, by-passing the operating valve and also the automatic terminal stop, as shown in Fig. 7, is dangerous, as, should this check give out, all the controlling devices are rendered inoperative, the hydraulic friction is greatly reduced, and the car will accelerate to a dangerous speed with nothing

to stop it until it strikes the bottom. In the writer's opinion such a check should be connected outside of the limit stop, so that in the event of failure of the check valve the limit stop would still be operative to stop, or at least retard, the car when it approached the bottom.

10 An accident occurred some ten years ago from the failure of such a check valve which would have been fatal to several persons had the check not been connected outside of the limit stop. It is preferable so to graduate the operating valve as to avoid the use of a check valve, and this has been done in several installations, but it involves careful design and graduation of the operating valve to meet the conditions of each particular case, and is, therefore, not considered commercial.

11 A comparison of the "high rise" plunger elevator machines in the Trinity Building, with high rise geared hydraulic elevator machines, is interesting. For such a comparison the writer has chosen the elevators of the Hanover Bank Building, Pine and Nassau Streets, New York City. Careful tests of these elevators were made in May, 1904, by Mr. J. R. Furman, Any type of pumping engine may be applied to any type of hydraulic elevator; hence, in making a comparison of elevator machines, we should compare the actual machines themselves, irrespective of the nature of the pumping plant, as, manifestly, with any given pump efficiency the final efficiency is entirely dependent on the efficiency of the elevator machine and, therefore, such a comparison should be made on the actual pressures used and actual displacements of the respective hydraulic cylinders when performing equivalent duties.

12 The Hanover Bank plant consists of six high rise and five low rise elevators, or eleven in all. In this comparison, high rise elevators only are considered. The six elevators have each a rise of 304 feet. The cylinders are 19 inches in diameter, and are geared 8:1. The pressure from an open reservoir, and constant, was 152 pounds per square inch.

13 From the tests the underbalance was found to be 810 pounds, the frictional resistance to be 690 pounds, and the mechanical efficiency 87 per cent.

14 The load and speed performances were as follows:

Speed with 180 lbs. in car, 940 ft. per min.	Stopping distance not taken.
Speed with 1000 lbs. in car, 815 ft. per min.	Stopping distance, 15 ft.
Speed with 1500 lbs. in car, 750 ft. per min.	Stopping distance, 10 ft.
Speed with 2000 lbs. in car, 645 ft. per min. Lost time, 4 seconds.	Stopping distance, 8 ft.
Speed with 2500 lbs. in car, 600 ft. per min. Lost time, 3½ seconds.	Stopping distance, 8 ft.
Speed with 2700 lbs. in car, 525 ft. per min.	Stopping distance not taken.

Speed with 3000 lbs. in car, 425 ft. per min. Stopping distance, 7 ft.
Speed with 3200 lbs. in car, 400 ft. per min. Stopping distance not taken.
Speed with 3400 lbs. in car, 300 ft. per min. Stopping distance not taken.
Speed with 3600 lbs. in car, 225 ft. per min. Stopping distance not taken.

Up motion hydraulic friction loss deduced from above data in pounds per square inch = .425 × (car speed in feet per second).

Running tests: round trip distance run 608 feet.
Load 600 pounds, 40 stops: 20 up, 20 down. Round trip, 3 minutes 22 seconds.
Load 600 pounds, 20 stops: 10 up, 10 down. Round trip, 2 minutes 26 seconds.
Load 1500 pounds, 40 stops: 20 up, 20 down. Round trip, 3 minutes 10 seconds.
Load 1600 pounds, 20 stops: 10 up, 10 down. Round trip, 2 minutes 30 seconds.
Load 1600 pounds, 20 stops: 10 up, 10 down. Round trip, 2 minutes 19 seconds.

15 On December 1, 1905, the writer timed the same elevators in ordinary service between 1:30 and 2 o'clock p. m., with the following results.

Nine round trips:

Fastest, 3 stops, 1 up, 2 down. Time round trip, 74 seconds.
Slowest, 10 stops, 4 up, 6 down. Time round trip, 106 seconds.
Average, 5⅔ stops; 3½ up, 2½ down. Time round trip, 95 seconds.
Average number of passengers, up trips, 6.
Average number of passengers, down trips, 4.

Thirteen stops were timed, varying from two seconds shortest to four seconds longest. Average stop, 2.8 seconds.

This is the time the car was actually at rest, discharging and receiving passengers.

16 By comparing the fastest and slowest runs it will be seen that the total lost time per stop, including retardation and acceleration, was a trifle less than 4.6 seconds. Deducting 14 seconds for three stops of quickest run, we find the running time to be 60 seconds; distance traveled 68 feet, or an average speed of 608 feet per minute. Hence these cars are traveling in service at the limit of speed for express elevators allowed by the Bureau of Buildings' Regulations.

17 From the speed load tests it will be noted that the elevators can carry 2500 pounds at this speed.

Taking the longest trip when ten stops were made	= 106 seconds.
Adding 4.6 seconds × 2 or two extra stops	= 9.2 seconds.
Time of round trip with 12 stops	= 115.2 seconds.
Hence, Hanover—time of round trip of 608 feet	= 1 min., 55.2 seconds.
Trinity —time of round trip of 537 feet	= 2 min., 14 seconds.

18 The Hanover time includes loading and unloading passengers, while in the Trinity tests the doors were simply opened and closed and no passengers handled.

19 The overrunning distance, *i.e.*, length of stop of the Hanover elevator, when at a speed of 750 feet per minute, with only 1500 pounds in car and an underbalance of only 810 pounds, was but 10 feet, while at only 490 feet speed with 1617 pounds in the car, and the large underbalance of 2135 pounds, the Trinity elevators required 12 feet 4 inches to stop in and lost 8½ seconds in getting back to the landing.

20 It is to be regretted that the lost time on this test at the Hanover Bank was not taken, but in the succeeding tests, with an eight feet overrun, the time lost was four seconds; hence, we can infer that in the previous case it was about five seconds.

21 From the tests given by Mr. Herschmann, it may be readily figured that the up motion hydraulic friction loss of the Trinity elevator is about, in pounds per square inch $= .78 \times$ (car speed in feet per second), or nearly double that of the Hanover Bank elevators. The Hanover Bank machine lifted 3600 pounds at 225 feet speed.

22 Mr. Herschmann does not give the load lifted at that speed, but from the data given it figures a little over 3000 pounds.

The mechanical efficiency Hanover Bank.....87 per cent.
The mechanical efficiency Trinity Building .....91½ per cent.

23 The excessive overbalance of the Trinity elevator, viz: 2135 pounds, necessary to overcome the momentum of the heavy moving masses, as against 810 pounds of the Hanover Bank elevator, makes the ratio of live load to gross load lifted 61 per cent, and 82.6 per cent, respectively, bringing the final efficiency or ratio of live load lifted to work done on plunger and piston for:

The Trinity elevator to.....56 per cent.
The Hanover elevator to .....72 per cent.

24 The plunger displacement of the Trinity elevator per car mile traveled = 4550 gallons, which, at 180 pounds pressure = 7.85 water horse power hours per car mile.

25 The piston displacement of the Hanover elevator per car mile = 4870 gallons, which, at 152 pounds pressure = 7.1 water horse power hours per car mile.

26 If we reduced the pressure of the Hanover elevator to that necessary to do the duty of the Trinity elevator, viz.: 3025 pounds at 225 feet, it would be 136 pounds instead of 152 pounds per square inch, and the power per car mile = 6.4 water horse power hours per car mile, or only 81.5 per cent of the power required by the Trinity elevator to do the same duty.

27 The argument is made that the plunger elevator is absolutely safe, and that this offsets any difference there may be in economy and service with high rises at high speeds. Let us consider this question:

28 There are no safety devices whatever on the Trinity machines except a top and bottom limit stop. This limit stop is operated by a wire cable, and is (see Fig. 7) separated from the cylinder by several tees, elbows, long nipples, etc., and also is by-passed by a check valve.

29 The test of No. 3 elevator shows that it can descend at a speed of 885 feet per minute = 14.75 feet per second with a load of 1756 pounds in the car.

30 The weight producing descent is therefore 1756 + 2135 pounds, underbalance = a total of 3891 pounds. Deducting the descending friction as given by Mr. Herschmann, viz: 300 pounds, leaves for production of speed 3591 pounds, which produced a speed of 14.75 feet per second.

The load $3591 \div 33.2 = 108.1$ pounds per square inch in cylinder.
The back pressure is said to be = 25 pounds per square inch.
Whence pressure producing speed = 83.1 pounds = hydraulic loss at 14.75 pounds speed, or

Descending hydraulic loss in pounds per square inch	$= 0.39\ V^2$
Of this the loss in the operating valve and automatic stop would be about	$0.16\ V^2$
In pipes and bends about	$0.06\ V^2$
And in cylinder itself about	$0.17\ V^2$
Total	$0.39\ V^2$

31 Hence, with a load in the car of say 2500 pounds, the car could descend and strike bottom at a speed of 980 feet per minute should the operating valve and terminal stop valve fail simultaneously.

32 Should the automatic check valve fail to close, the hydraulic resistance of the operating and terminal stop valves would be entirely eliminated and the total hydraulic resistance reduced to about .23 V^2, and the car would strike at a speed of 1280 feet per minute.

32 Should the "to and from pipe" give way, the hydraulic resistance would be reduced to about .17 V^2, the back pressure of 25 pounds would be gone, and the car would strike the bottom at a speed of 1660 feet per minute. The result of such an occurrence requires no comment.

33 The writer is of the opinion that the plunger, or any other type of elevator, should be provided with automatic regulators, preventing excessive down speed, and in addition be provided with retarding devices, independent of the operating machine, which will stop the

car under any condition of loading in a long enough distance to prevent injury to the passengers at the highest speed at which the car can reach the bottom.

34. Sufficient pit room should always be provided at the bottom of an elevator shaft in order that this result may be accomplished. It is to be regretted that this is rarely done.

35 The diagrams and comparative table, herewith, will show these comparisons more conveniently.

	Trinity	Hanover
Type	Plunger	Geared Hydraulic
Rise	282 feet	304 feet
Diameter of ram and cylinder	6½ inches	19 inches
Gear-ratio, car to piston travel	1:1	8:1
Pressure	180 pounds	152 pounds
Areas	33.2	278
Maximum lifting force $= \frac{\text{area} \times \text{pressure}}{\text{gear}} =$	5976	5300
Mechanical efficiency	91.5 per cent	87 per cent
Mechanical friction	500 pounds	690 pounds
Underbalance	2135 pounds	810 pounds
Effective lifting force at 0 speed	3341 pounds	3800 pounds
Lifting efficiency (live load)	56 per cent	72 per cent
Hydraulic loss in terms of car velocity in feet per second	$0.78\ V^2$	$0.425\ V^2$
Moving mass at car velocity	= 22,035 pounds	9500 pounds
Underbalance required for equally short stops	2980 pounds	810 pounds
Overrun (stopping distance) with 1617 pounds at 490 feet	12 feet 4 inches	
Overrun (stopping distance) with 1500 pounds at 750 feet	10 feet	
Overrun equated to load and velocity	12 feet 4 inches	4.15 feet
Trinity, 537 feet travel. Hanover, 608 feet travel: Time of round trip, making 12 stops	2 m. 14 s.	1 m. 55.2 s.
Time of round trip reduced to 537 feet travel	2 m. 14 s.	1 m. 48 s.
Speed with 1500 pounds load (see curves)	522 feet	750 feet
Speed with 2500 pounds load (see curves)	350 feet	600 feet
Speed with 3000 pounds load (see curves)	232 feet	425 feet
Gallons displacement per car mile	4550	4870
Water horse power hours per car mile	7.85	7.1
Water horse power hours reduced to same load and speed	7.85	6.5
Ratio of power used for same useful work	1.000	0.825

MR. WILLIAM H. BRYAN I desire to make a record here of what appears to be the most efficient hydraulic elevator plant in operation.

It consists of ten plunger machines in the May Co. department store, St. Louis. Their service is as follows:

a Three passenger cars, rated load 2500 pounds, maximum, 3000, travel 80 ft. 6 in.

b Three passenger cars, same loads, travel 68 ft. 6 in.

c One passenger car, same loads, travel 75 ft.

d Two freight cars, rated load 3000, maximum 3600, travel 85 ft. 6 in.

e One freight car, rated and maximum loads 2750, travel 14 ft. 6 in.

2 The plant was installed within the last year by the Standard Plunger Elevator Co., of New York. Previous to contracting for it the May Co. had entered into an agreement to purchase its entire power and lighting service from an outside central electric station. This necessitated that these elevators be driven by electric pumps. These pumps were included in the elevator contract, and consisted of three Allentown single acting triplex pumps with vertical plungers, 9″ diameter, 10″ stroke, each direct chain driven by a 50 horse power Bullock electric motor, designed for 480 volts direct current. Speed of pumps, 50 revolutions per minute; motors, 300. The installation was made under a very stiff guarantee as to efficiency, and the contractors were given a free rein as to the methods by which they could cut down current consumption. They therefore installed what they called a double pressure system, but in reality there are four different pressures in use, two working and two discharge, with two independent working pressure tanks and two independent discharge tanks. By means of regulating and check valves the ascending car automatically selects its water from either of the two working pressure tanks. The higher of which carries about 150 pounds pressure and the lower about 120. Light loads are served by the lower of these two pressures, and heavy loads by the higher. Descending, the car again selects the discharge tank into which it will deliver its water, the higher of the two tanks usually carrying about 45 pounds pressure and the lower about 15 pounds. Lightly loaded cars discharge into the low, and heavily loaded into the high pressure discharge tank. It will be noticed that the net working pressure on the pumps for both empty and loaded cars making round trips is about 105 pounds.

3 This arrangement differs from previous multiple pressure systems which have come under my observation in that the heavily loaded descending car discharges its water against a high pressure, which pressure is available for reducing the work on the pumps.

These latter automatically select high pressure water on their suction side, so long as it is available, and when it fails they take water from the low pressure tank.

4 A recent test was made with the passenger elevators making round trips every two minutes, the two freights every five minutes, and the short lift every two minutes, stopping at all floors, the cars carrying their full rated loads. For this service one pump was in continuous operation, and a second 25 per cent of the time, the third being idle, in reserve. The working pressures were changed slightly for this test, loading as follows: working; high 149, low 118.5; discharge; high 38.6, low 16. The efficiencies were found to be 4.05 kilowatt hours and 4.30 water horse power hours per car mile of travel, a result which, so far as I can learn, has never before been reached for heavily loaded cars.

5 The apparatus is the invention of Mr. Thure Larssen, Chief Engineer of the Standard Plunger Elevator Co.

MR. E. S. MATTHEWS This paper gives us a series of observations on the Trinity Building direct acting plunger elevators from which valuable conclusions may be deduced regarding the suitability of such elevators for high buildings.

2 We do not find any statement of the maximum net load raised at slow speed, but this is readily deduced from the data given.

3 However, an observation on this point is always valuable, for it gives the basis for determining the mechanical efficiency of the machine, and also a valuable point in plotting speed curves; furthermore, by a comparison of this load, which is quickly and easily made, with the total hydraulic lifting power of the water, a rough conclusion may be at once drawn as to the economy of the apparatus.

4 From Mr. Herschmann's data this elevator under 177 pounds pressure will raise 3218 pounds slowly, while the total lifting power of the water is 5873 pounds; or the elevator carries continually somewhat over a ton and a quarter of dead weight up and down the hatchway, giving a maximum live load efficiency of 55 per cent.

5 This must be considered a little disappointing as high rise high speed hydraulic elevators commonly show 70 per cent. This was the result of tests in the Stock Exchange Building, Woman's Temple, Teutonic Building, and others at Chicago, while in a test at the Masonic Temple and Great Northern Office Building, also at Chicago, the live load efficiency was much higher than 70 per cent.

6 The cost per car mile travel of 5.22 cents and 8.04 cents with compound duplex and high duty pumps, respectively, must also be

considered wasteful when we compare the performance of the Teutonic Building and others of its class, where the elevators with compound duplex pumps were run at about four cents per car mile while two cents per car mile has been repeatedly guaranteed and surpassed by high speed hydraulic elevators with high duty pumps.

7 This matter of fuel economy might be gone into quite exhaustively, but all engineers agree that it is of minor importance unless it assumes abnormal variation from customary standards; and as far as these elevators are concerned, the subject may be dismissed with the simple statement, that the fuel cost of their operation is about 50 per cent more than that of other well designed hydraulic elevator plants, giving higher and faster service.

8 Mr. Herschmann has given us some notes and observations on what might be called running tests of these elevators, which is a valuable departure from the ordinary, and which form an interesting portion of his paper.

9 At the bottom of p. 419, he gives us the result of what he designates as a "flying test" with a load of 1617 pounds in the car. The object of a "flying test" is to determine the highest speed attainable in a given elevator and the conditions of upward stop under these circumstances. The load for a "flying test" should be as light as possible.

At a "flying test" in the Masonic Temple at Chicago, the Equitable Building, Atlanta, Ga., and others, the load in the car consisted only of the writer and one other person.

10 In Prof. Alden's paper on the Plunger Elevator, presented at the Washington meeting of our Society in May, 1899, in discussing this subject, he takes the car with no load whatsoever at its maximum speed, and at the top of the hatchway.

11 To make a "flying test" with a car loaded with nearly a ton would seem to be inadvisable and such a test could be better designated as a "running test with a well loaded car."

12 However, the omission of this observation is not a serious matter, as we can easily deduce the results of such a test from the data given us by Mr. Herschmann.

Let V = velocity of the elevator in feet per second.
Let R = the retardation or minus acceleration of the system under the given conditions.
Let B = Net retarding force in pounds.
Let D = Distance traversed in feet in coming to rest.
Let Q = Total pounds weight moved at car velocity.
Let l = live load in the car in pounds.

Let p = the total plunger weight in pounds.
Let f = pounds weight of frame and panels.
Let c = pounds weight of car.
Let r = total pounds weight of counterweight ropes.
Let b = pounds weight of counterweight ropes unbalanced so as to produce ascent (which may be + or − according to the location of car in hatchway).
Let w = pounds weight of fixed counterweight.
Let u = upward friction of elevator in pounds.
Let h = total upward back pressure on plunger in pounds.
Let g = acceleration of gravity in feet per second.

13 Let the elevator be in upward motion, and the hydraulic pressure causing such ascent to be cut off.

Then

$$D = \frac{V^2}{2R} \qquad [1]$$

and

$$R = \frac{B}{Q} g. \qquad [2]$$

$$B = p + f + c + l + u - w - b - h \qquad [3]$$

$$Q = p + f + c + l + r + w \qquad [4]$$

The value of R in a properly designed high speed hydraulic elevator is about 6 *when the car is lightly loaded.* A mental calculation shows that this will produce a natural stop when running at 600 feet per minute in $8\frac{1}{3}$ feet.

14 The values of R in the Trinity Building elevator are as follows:

When loaded with operator weighing 150 pounds,

$$R = 2.96 \qquad [5]$$

When loaded with 1617 pounds,

$$R = 4.77 \qquad [6]$$

At a speed of 600 feet per minute

$$D = \begin{cases} \text{with 150 pounds load} & 17 \text{ feet} \\ \text{“ 1617 “ “} & 10\frac{1}{2} \text{ feet} \end{cases} \qquad [A]$$

At a speed of 490 feet per minute

$$D = \begin{cases} \text{with 150 pounds load} & 11 \text{ feet} \\ \text{“ 1617 “ “} & 7 \text{ feet} \end{cases} \qquad [B]$$

15 These tabular results indicate the shortest possible stops of this apparatus made by a theoretically perfect controlling valve and

they cannot possibly be made shorter; but actual practical stops exceed these by a considerable amount even with the best controlling valves. Mr. Herschmann's paper gives these actual stopping distances and we learn that with a load of 1617 pounds, at 490 feet per minute, the actual stopping distance was 12 feet 4 inches, instead of 7 feet, as shown by the above table, or that the controlling apparatus took about two times the distance in stopping that the shortest natural stop of this apparatus calls for.

16 Both the overrunning distance and time lost are about twice as great as would be permitted in good practice.

17 The results of the running tests, opening and closing doors, etc., are remarkable, and when the nature of the controlling apparatus, and the small valves of *R* are taken into account, they must be considered as highly creditable to the elevator operator.

18 On the first page of Mr. Herschmann's paper he alludes to an economy of 5 per cent through the action of an automatic valve operating on the up stops.

19 It would be interesting to know from what observations the result was deduced; for this valve can deliver no water to the elevator during normal operation, unless the stop is made as short as the laws of gravity and momentum will permit. In the observation just spoken of it took about two times as long to make the stop as these natural laws called for, and briefly there does not seem to be a single observation in Mr. Herschmann's paper where this valve could have possibly delivered even a drop of water into the system.

20 The writer would have been glad to have the opportunity of analyzing a series of observations supporting any such claim, and would suggest that a computation of probable error of the result would undoubtedly have found such error to exceed 5 per cent.

21 Only the high rise elevators are equipped with this back pressure check valve device, the low rise elevators being provided with an entirely different apparatus; both of these devices are intended to prevent the plunger from leaving the water in case of defective operation of controlling valves, and the back pressure device accomplishes quite another important additional function, which is undoubtedly the reason for its use.

22 The check valve designated by Mr. Herschmann as the automatic valve is merely an incident in the case. This check valve is an old device and no claim for economy has ever been made for it.

23 The back pressure check valve device is simply the employment of a water counter-balance; and that is evidently the reason why it was used on the high rise elevators only.

24 The short rise elevators having less mass in motion are easier of control, and we have seen that in the high rise elevators, even with the employment of water counter-balance, the values of R become much less than is sanctioned by good practice.

25 As the value of R decreases, the elevator approaches the absolutely uncontrollable state and it may be interesting to see how the use of the water counter-balance increases the value of R and, therefore, renders the elevator more controllable.

25 Referring to equation [2] we see that

$$R = \frac{B}{Q}\, g, \qquad [2]$$

or substituting the values in [3] and [4] for B and Q, we have

$$R = \frac{p+f+c+l+u-w-b-h}{p+f+c+l+r+w}\, g. \qquad [7]$$

26 If we now diminish the value of w and add the same amount to the value of h, the value of the numerator of this fraction is unchanged but the value of the denominator is decreased; hence R is increased and the elevator is rendered more controllable.

27 The subject of elevator control is worthy of serious consideration for it has more to do with the safety of passengers and the rendering of efficient service than any other problem connected with an elevator installation.

28 In Mr. Herschmann's paper he gives us in Figs. 1 and 2, elevation and plan of Trinity elevators showing plunger casings, valves, and automatics at the lower landing, and in Fig. 6, he gives us a sectional elevation of the pilot controlling valve and terminal automatic stop valve. These drawings were furnished him by an official of the company installing the elevators, as stated in his paper, and approved and offered for publication in our Transactions by him.

29 An oversight has occurred on the part of these gentlemen, for the sectional elevation of pilot controlling valve and terminal automatic stop valve represents another apparatus entirely from that in use in the Trinity Building.

30 The section shown is that of a valve of simpler design and more attractive appearance than that in the Trinity Building, but for the sake of scientific accuracy the writer suggests that it would have been consistent and proper to have shown the actual valve in use.

31 However, the writer is able to remedy this oversight and submits herewith (Fig. 1) a sectional elevation of the pilot controlling and terminal automatic stop valve in actual use in the Trinity Building.

32 The drawing submitted by the writer will be found to agree with the plan and elevation of Fig. 1 and Fig. 2 of Mr. Herschmann's paper, whereas the section submitted by him is at variance with these figures.

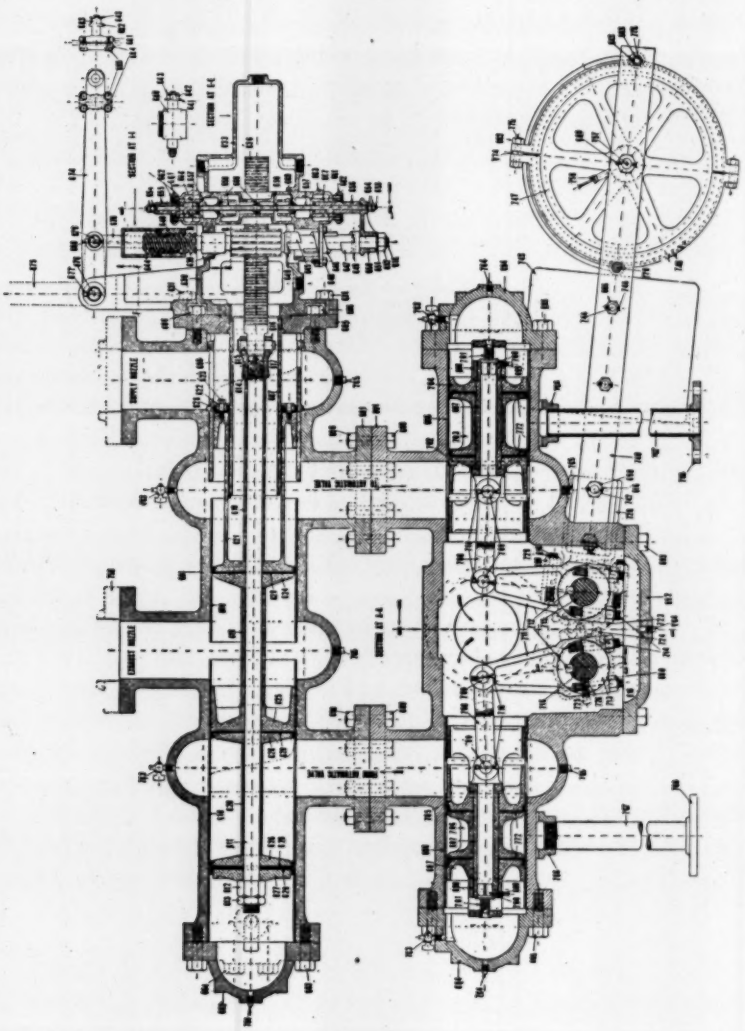

FIG. 1 PILOT CONTROLLING VALVE AND TERMINAL SAFETY STOP VALVE IN ACTUAL USE AT THE TRINITY BUILDING

33 This mechanism will be seen to be of considerable complexity but it is interesting to note how the substitution of a hollow-plunger

for the telescoping cylinders, shown at the upper right hand of the valve structure, would have simplified the apparatus, diminishing its necessary diameter, length, and number of parts avoiding the special –U packings and obviating heavy dragging weight upon the valve lining. The modification of this valve is shown in diagram as Fig. 2.

34 The motion between main and pilot valves in the Trinity Building is accomplished by a rack, pinion, screw, suspended nut, and connecting bracket. The simplification of this motion and the avoidance of lost motion is shown by an inspection of Fig. 3 which represents the connecting motion of the Moore Patent, consisting of a single lever. This patent was once owned by the Crane Elevator Co., but expired long

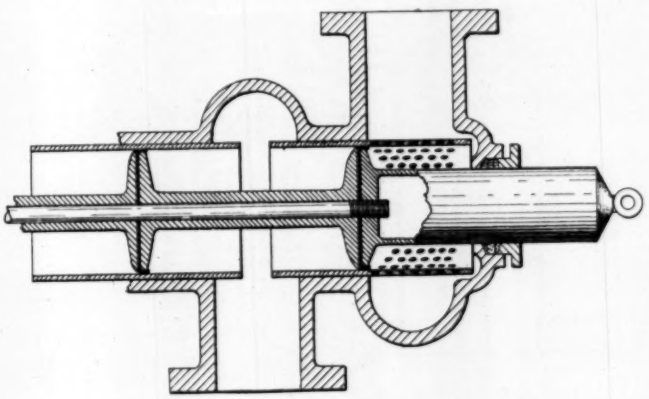

FIG. 2 SIMPLIFICATION OF SUPPLY PART AND ACTUATION AREA OF CONTROLLING VALVE SHOWN FIG. 1

NOTE—This construction was in use and published about half a century ago; and illustrates the fact that some modern devices are not improvements on "the work of the ancients."

since and has been for years public property. The suspended nut on the Trinity Building valve motion is prevented from revolution only by the directive tendency of two links whose resistance to torsion is governed by short bearings; and an inspection of the actual working construction at the Trinity Building now shows a lost motion at this point of something like a quarter of an inch. These are the mechanisms by which the operator controls the operation of the car and a motion of the pilot valve of about an inch is all that is required to differentiate between full speed and absolute stop. It should be comparable in positiveness and simplicity to a locomotive throttle, but the valve motion of the Trinity Building is really so wide a

departure from the previous practice of engineers as to call for more than a passing notice.

35 The terminal automatic stop valve here shown is operated by two traveling wire cables extending four times up and down the

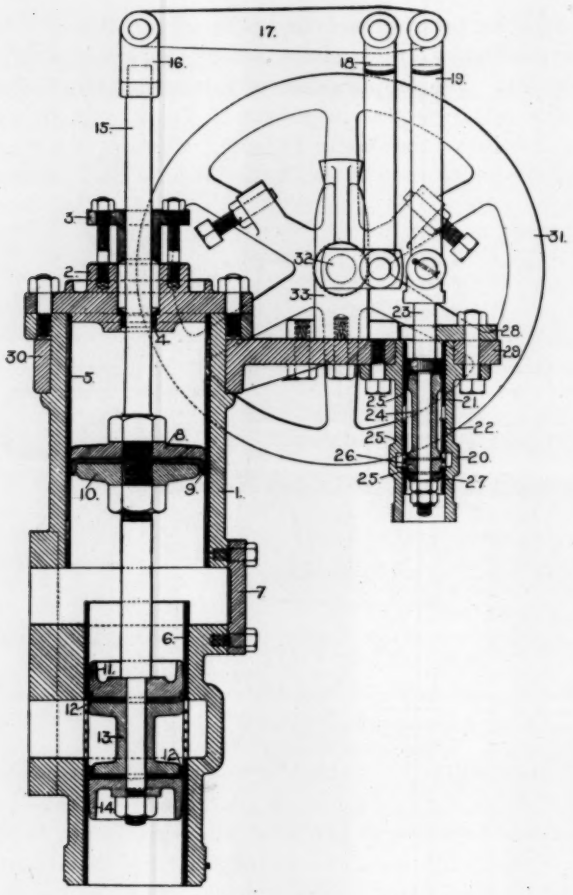

FIG. 3 THE SIMPLE AND EFFECTIVE VALVE MOTIONS OF THE EXPIRED MOORE PATENT

hatchway, each about 600 feet long. The approved previous practice has been to cause the action of such safety stop in some absolutely positive manner by rigid transmission of iron to iron, and Fig. 4

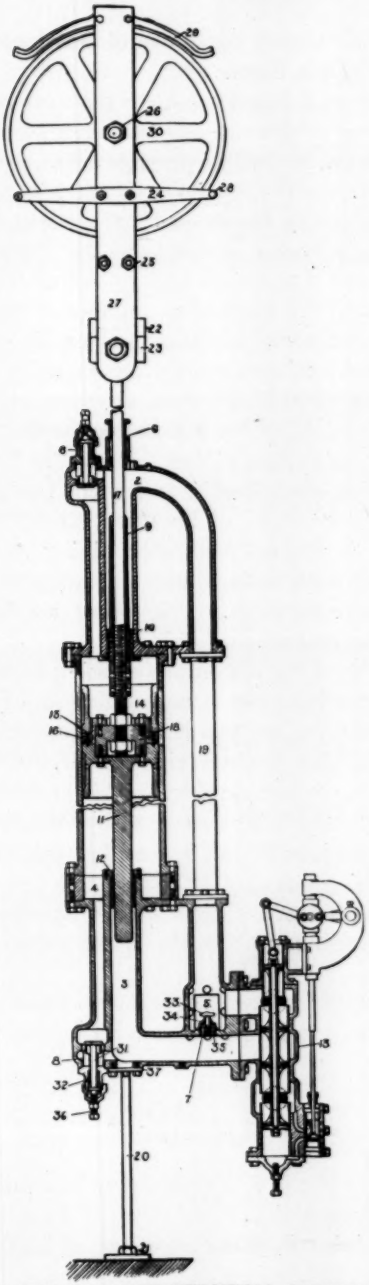

FIG. 4 THE SIMPLE AND POSITIVE TERMINAL SAFETY STOP DEVICE OF BASSETT

shows the device of Bassett consisting of cones positively carried by the motion of the piston itself.

36 It is to be questioned whether the actuation of a terminal safety stop by long cables subject to stretch, wear, and kinking, or jumping from wheels, as well as possible breakage, is a departure in the right direction.

37 It being generally conceded by those who know that in case of failure of piping valves or connections the plunger elevator having no safety device will descend at high speed with serious results, the question arises as to the respective chances of piping failure in the plunger elevator and cable breakage in the cable elevator.

38 The cables of an elevator are always readily seen and inspected whereas the piping connections of an elevator are often subjected to severe and hidden initial stress due to the drawing together of joints in "making up." Elevator piping failures are by no means infrequent; water mains often break, and when the plunger elevator is stopped and the momentum of its mass (about eleven tons in the Trinity Building) is checked, elevator piping and connections are strained in a much more serious manner than are the cables or piping of a cable hydraulic elevator. The writer considers that the two risks are about equivalent.

39 Let us examine the conditions existing as regards plunger and casing when the car is at the lower landing and full lifting power is exerted by the machine, as this is the landing where the car is fully loaded. The maximum pressure given in Mr. Herschmann's paper is 190 pounds per square inch, and when this pressure is applied to the lower end of the plunger it is augmented by the pressure due to a submergence of the plunger of 282 feet or 122 pounds per square inch, making a total lifting power of 10,352 pounds upwardly exerted upon the bottom of the plunger. This will not only raise the plunger itself (8460 pounds) but will cause the plunger to carry as a column a load of 1893 pounds.

40 As this plunger is fixed in direction at the top by a long brass sleeve the formula applicable to ascertain the conditions is that of Euler, viz:

$$P = 2\,\pi^2\,\frac{EI}{L^2} \qquad [8]$$

When P = ultimate load, I = moment of inertia, L = length, and E is the modulus of elasticity.

41 For the Trinitv Building elevators, E is 30,000,000, L is 3384 and I is 35.

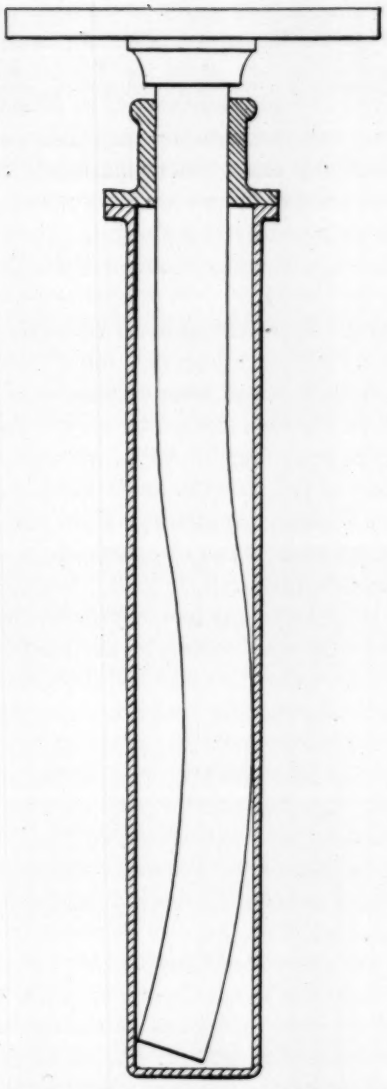

FIG. 5 (NO SCALE) DIAGRAM ILLUSTRATING THE BUCKLING OF LONG AND SLENDER PLUNGERS WHEN LOADED AT THE LOWER LANDING

42 A brief computation shows that the plunger would not hold itself up unless confined by its casing. What actually happens is this: The plunger bends against the casing, its lower end and upper convexities of buckling arcs dragging and grinding against it. This is illustrated by Fig. 5. The upper point of grinding on the plunger itself, theoretically, would occur at a distance of $\frac{L}{2\sqrt{2}}$ from the lower end of the plunger, but the variation in thickness of the tubing is sufficient to prevent any exact determination at this point; and in fact more than one point of flexure may occur and in some cases the corkscrew form is assumed by the plunger. I am informed that it has been found necessary to renew numerous plunger bottom sections in practice in various buildings. But a most serious question is in regard to the casing. It would seem to be costly if not altogether impossible to renew casings as deep as those of the Trinity Building; and if about two or three years' wear causes renewal of plunger bottoms, the wear upon the casing must be very appreciable.

43 Regarding the test of the multiple pressure system of hydraulic plunger elevators at the May Co. department store St. Louis, Mo. submitted by Mr. Bryan, I would say that the economy stated cannot be verified by an analysis of observations on account of the insufficiency of the data given.

44 The result is by no means remarkable for the pressures "were changed slightly for this test loading," thus employing the pressure in discharge tanks (or really the water counterbalance) in such a way as to secure maximum economy under the conditions of "this test loading."

45 Or exactly the same results of economy are obtained as in the case of specially adjusted counterbalance weights which might be arranged with reference "to this test loading."

46 Regarding the comment "a result which, so far as I can learn, has never before been reached for heavily loaded cars," I would call attention to the gravity lifting type of geared plunger elevators such as is installed in the American Tract Society Building and others where maximum economy is obtained with a full loaded car (where the energy consumed in its operation is merely the expenditure of work sufficient to overcome friction).

47 The multiple pressure system of operating hydraulic elevators is not new; the only question regarding it is a practical one, viz: Is the gain in economy worth the necessary expense of the complications involved in such a system? The experience of engineers thus far has answered this question in the negative.

48 In the course of development in every special line of the mechanic arts the lines of advance may be said to assume an angle dictated by good engineering practice in that particular line.

49 But occasionally abrupt divergences from such an angle occur, occasioned on the one hand in a normal manner by the advent of a meritorious basic invention, or on the other hand by a sporadic departure due usually to commercial exigencies merely. An example of the former is perhaps the steam turbine, and examples of the latter class are not wanting.

50 The writer has not given an exhaustive analysis of the elevators under discussion; to do so would be to write a book on the subject. He has called attention to a few considerations deemed to be important in a suggestive manner only, leaving the interested engineer to decide for himself in which class elevators such as these under discussion belong.

51 It is well to determine the result of some problems experimentally; and that of the comparative utility of plunger elevators for high rises is being rapidly advanced toward solution by that method.

MR. FREDK. MERIAM WHEELER As particular emphasis is given in Mr. Herschmann's paper to the relative economies of the two types of elevator pumps used, it would have been well to have had each set of pumps properly designated and perhaps a brief description given. They are simply referred to, respectively, as a "duplex compound pump" and "a high duty fly-wheeel pump"—very incomplete and misleading names.

2 If I remember correctly, the former was a pump of the direct-acting type (running at the slow speed of 12 double strokes per minute on each side) and the latter a pump of the cross compound triplex type (averaging 25.7 revolutions per minute) having one high-pressure steam cylinder, two low-pressure steam cylinders, and three water cylinders.

3 Not only had the triplex pump the advantage of more economical steam distribution but its greater speed added much to its economy.

4 The paper would also have been more complete if indicator cards from the water cylinders of each pump had been given. It certainly would have been an interesting study to compare the cards from the two water cylinders (each of which were double acting) of the direct acting compound duplex pump with the cards from the three water cylinders (each of which were single acting) of the crank and fly wheel cross compound triplex pump.

A HIGH DUTY AIR COMPRESSOR

By Prof. O. P. Hood, Published in November Proceedings

Mr. W. L. Saunders It is proper to call attention to the fact that the paper before the Society is to be regarded as a steam engine paper and not as dealing with the ultimate efficiencies of the unit as an air compressor. How completely the air compressor is ignored may be inferred from the fact that nowhere in the paper are we told what weight or volume of air was compressed and delivered per pound of steam consumed.

2 In the ten hour run the pressure only varied two pounds and the speeds had a uniformity not consistent with common practice. We have to assume that to maintain the approximately constant load as reported the air was at times blown off or wasted.

3 It will be noted that for this quadruple expansion engine the consumption of dry steam per i.h.p. hour (p. 237) is 11.23 pounds. There is a report by Mr. Geo. H. Barrus and Mr. Geo. I. Rockwood of a test of a Cooper Corliss two cylinder compound engine at Atlantic Mills, Providence, in which the steam consumption was 11.22 pounds. This is the same type of engine often used on Ingersoll Rand Corliss air compressors. So far as steam consumption is concerned no gain has apparently been achieved by the Nordberg quadruple expansion engine over the Cooper two-cylinder engine.

4 A coal test of the Cooper engine was made by Mr. Barrus showing a result of 1.229 pounds per i.h.p. hour. This includes the operation of the steam driven auxiliaries, which would under the best conditions greatly exceed the consumption of the Nordberg engine-driven auxiliaries. The amount of steam used by the air pump, including leakage of the plant, by actual test, amounted to 20 per cent of the whole, while the Nordberg auxiliaries required only a little over one per cent of the horse power of the engine The air pump pistons in the Cooper case were in such bad shape that the loss due to this cause alone was estimated by Mr. Barrus at 3 to 4 per cent of the total coal consumption.

5 No actual coal test was made in the Nordberg case, so far as we know; the coal consumption of 1.016 pounds per i.h.p. hour is based upon an assumed calorific value for the fuel and an assumed boiler efficiency.

6 The Cooper test is an actual commercial result, achieved with 175 pounds steam pressure as against 250 in the Nordberg, and also under very disadvantageous conditions so far as auxiliaries are concerned. Allowing for these conditions, we think the Cooper performance at least equal to the Nordberg.

7 Alluding to the air end, the compression line of each card at the very beginning of the stroke is quite perceptibly above the atmosphere line. Now, we understand that in filling the air cylinder the air is not pulled in but is pushed in by the pressure behind it, and that to cause the air to flow into the cylinder there must be some excess of pressure outside the cylinder or some deficiency of pressure within it. If the four cards from the two ends of the two air cylinders all showed the pressure to be higher in the cylinder than outside of it before compression began, the phenomenon is so remarkable as to require indisputable evidence to confirm it.

8 In paragraph 34, the volumetric efficiency of the air compressor is stated as 98.43 per cent, but it does not appear how this was computed and what has just been said may explain this extraordinary result, for, referring again to Fig. 17, the net clearance of the low pressure or intake cylinder is 2.61 per cent. This clearance is of course filled at the end of the stroke with air at the delivery pressure for that cylinder, 34.26 pounds, absolute, which compared with the intake or free air pressure of 13.96 pounds shows 2.45 compressions and the free air clearance value is then 6.39 per cent instead of the 1.57 per cent required to give the stated efficiency of 98.43 per cent and this difference would of course affect the other results given. If the intake was really above atmosphere that might affect the clearance value, but if so we should have some detailed explanation of it.

9 This attempt to advance the art of steam engineering is to be commended, and the processes of regenerative feed water heating are most interesting; but here we have a quadruple expansion engine of complex design with the attendant difficulties of very high pressure steam, refined condensing and other apparatus to promote net efficiencies, and yet the results secured, under conditions carefully adjusted for test purposes, do not show any economy in the steam consumed in the engine over those secured from the simplest form of two-cylinder Corliss compounds of about the same horse power but under commercial conditions of steam pressure, etc. It is open to grave question whether it is advisable to use reheaters, for feed water heating while the flue gases are allowed to escape at high temperatures unutilized by economizers or otherwise. It would seem that most mine operators will continue to prefer the simpler type of machine capable of giving quite as good net results and within the abilities of the ordinary class of engineers.

VENTILATION OF THE BOSTON SUBWAY

By H. A. Carson, Published in October Proceedings

Dr. G. A. Soper The writer does not hold the view that the ventilation of the New York and Boston subways without fans has been proved to be a failure and that mechanical ventilating devices are indispensable in subways built near the surface of the ground.

2 If we take for our guide the results of air analyses, it must be admitted that very little is known concerning the Boston subway. The analyses printed in the reports of the Transit Commission and reproduced by Mr. Carson are far too few and, perhaps, Professor Carmichael, who made them, would permit the writer to say, not sufficiently representative to warrant the deductions of far-reaching importance which are now made with regard to them.

3 If, as has been suggested, we cast aside the results of air analyses and trust implicitly to that unreliable sentinel, the nose, we are still more likely to be led astray.

4 The remedy for a bad smell is not always more air. It is often feasible to get rid of an unpleasant odor once and for all by removing its cause. There is no subway anywhere, so far as the writer is aware, where unpleasant odors do not occur and where these odors could not be greatly reduced by closer attention to comparatively inexpensive details of construction and operation.

5 So far as the condition of the air in the New York subway is concerned, Mr. Churchill apparently holds far different opinions from the writer. There are the results of 5000 analyses to show that the general air in all parts of the subway was satisfactory from chemical and bacteriological standpoints before the present changes in ventilation were made. The most objectionable conditions were the heat and odors, and possibly the dust. Of these the heat and odors were the most obviously objectionable; the heat for about four months of the year; the odors continually. Without the odors the heat would be far less noticeable.

6 To meet these difficulties, mechanical fans were installed and blow holes, some of which were provided with check valves. Mechanical ventilation was not, however, the only measure of relief which a careful study of the case suggested.

7 More time and much more careful observation than have thus far been devoted to the subject of subway ventilation are needed before we should speak dogmatically with regard to methods which are both necessary and sufficient for ventilating subways. In the writer's view, the art, if art it can be called, is in its infancy.

8 In considering the condition of air in the New York subway, confusion must not exist between conditions which are general and those which are local. The unpleasant and unwholesome conditions connected with overcrowding at some of the stations and often in the cars are local. In the writer's view it is not improbable that the best measures to adopt to improve these conditions would be local ones.

9 To increase the frequency with which the air is renewed throughout the subway with the hope of relieving the conditions in a densely packed and badly ventilated car is to attack the problem at extremely long range. Especially is this true when the general air of the subway is already good.

10 The writer would like to know what method of analyses Mr. Churchill used when he found 1.75 and 1.76 parts of carbon dioxid in the air of the streets of London and Paris, respectively? These amounts are exceedingly small.

11 Very accurate analyses made in France by Reiset gave 2.96 as the amount of carbon dioxid present in normal air. The records of the Montsouris Observatory at Paris give, as an average of observations covering thirteen years, 3.14. Schultze at Rostock made a daily analysis of air for four years and gave, as his average of all results, 2.96. Angus Smith reported that the air among the Scotch hills contained 3.36; the air of Manchester, 4.03; of Perth, 4.14; of Glasgow, 5.02. Rosecoe and M'Dougall found 3.92 parts of CO_2 in Manchester air. J. S. and E. S. Haldane made the figure 3.0 volumes for country air and G. F. Armstrong, 3.13. Petenkoffer's figure was 3.5.

12 In London, Angus Smith found in the parks, 3.01; in the streets, 3.80; and, as the average of thirty-five analyses of air from different parts of London, 4.39.

13 The most careful long series of analyses of London air were made by Russel who, as the result of one hundred and fifty-nine determinations, announced 4.03 as the average for the center of London. Russel's smallest figure was 3.0.

14 A few years ago, Butterfield was instructed by the committee of the House of Commons to determine as exactly as present scientific methods would allow the actual condition of the air of the debating chamber when in use. In this investigation, the outside air of London, as it entered the ventilating apparatus, was found to contain 3.37 parts of CO_2 with a maximum of 3.74 and a minimum of 3.14.

15 In the writer's investigations for the New York Rapid Transit Commission over 2000 carbon dioxid determinations were made of subway air and air from the streets through which the subway

passed, with the result that the average of the results of analyses of outside air was 3.67, with a maximum of 5.61 and a minimum of 2.69.

16 Mr. Churchill's reported findings of 1.75 and 1.76 parts of CO_2 in the air of London and Paris are therefore of considerable scientific as well as practical interest.

MR. THEO. WEINSHANK The points which were omitted by Mr. Carson and which I intended to bring out during the discussion, were almost fully covered in the written discussion by Professor Woodbridge. There is only one point on which I do not agree with Professor Woodbridge, and that is the selection of the fans used for the ventilation of the Boston subway.

2 It may be true that the fans were selected, after experiments and investigations, but, omitting the question of the efficiency of the different fans, the fact remains that the horse power required to deliver a certain amount of air per minute against a certain resistance is the same in all cases for all fans.

3 This being true and considering the fact that the efficiency of the disc or cone fan is greater when it is discharged against atmospheric pressure, and also that the efficiency of the disc or cone fan rapidly decreases as the velocity of the fan increases, I do not see why an enclosed fan or the so-called blower was not used for the ventilation of the Boston subway. Especially so since Professor Woodbridge states in his discussion that in the course of years the subway will be more or less contaminated and the fans will be called upon to perform a greater duty in handling a great deal more air, or make a more frequent change of air. This cannot be accomplished by the fans now installed, which are working at their maximum efficiency and capacity.

4 It has been the writer's experience that the disc or cone fans are too much affected by atmospheric changes and this is another reason why the writer is criticising the installation of the disc fans.

5 As an illustration of the difference between disc fan and the enclosed radial fan, or blower, I would compare the disc or cone fan with a screw propeller and the blower with a side-wheel propeller. If the waves of the ocean would permit, our seagoing vessels would all be side wheelers, as they are more positive and more efficient.

6 The ventilation of the subway is a matter of prime importance, as Mr. Carson has brought out in his valuable paper. Such being the case, and even admitting as Professor Woodbridge states, that the power consumed by the blowers would be greater than that which is consumed by the disc or cone fans, the investment would still be

justified, as the elasticity of the blower is greater, and when called for, an increase of ventilation in the subway could be easily accomplished by increasing the speed of the blower fan, which can not very well be accomplished by the disc or cone type fan.

BOILER AND SETTING

By A. Bement, Published in November Proceedings

Mr. Albert A. Cary In the simplest setting of a Babcock & Wilcox type of boiler, where the grates are placed immediately below the first pass of the tubes, we have about as poor a furnace construction for the use of bituminous coal as could be designed.

2 It is generally understood that the combustion of bituminous coal is a two stage process:

a the driving out of the gases occluded in the coal by heat; and

b the burning of the solid combustible matter left behind, which latter combustion occurs on grates.

3 The first step of this process is a distillation of volatile gases from the coal. We next find these gases rising into the combustion chamber above where they are consumed more or less rapidly, according to the temperature existing there, or else extinguished and not burned if this temperature is below their critical temperature of ignition.

4 As combustible gases also require more or less time (especially if diluted with non-combustible gases) they should not be rushed, even through a very highly heated chamber at too high a rate of speed to allow them time to ignite and burn to completion before coming in contact with the comparatively cold boiler parts.

5 The presented surface of the tubes is seldom more than a few degrees hotter than the water they contain, so that in a boiler carrying a steam pressure of 150 pounds, we cannot look for a tube temperature of much over 365 degrees, while the temperature of the unconsumed furnace gases should not fall below 1800 degrees.

6 With the simplest form of setting in a Babcock & Wilcox type of boiler, we find the volatile gases leaving the fire bed and rushing upward into a bank of practically cold tubes.

7 With anthracite coal containing very little volatile matter, we find this form of setting very desirable and with semi-bituminous coals, carrying less than 20 per cent of volatile matter, we find good results obtained, but the grate must be removed to a greater distance below the tubes than when anthracite is used. Baffle bricks between the tubes to retard the velocity of the gases are also found desirable,

but when we go farther west and find coals running from 30 per cent to 50 per cent in volatile matter, which shows that from $\frac{1}{3}$ to $\frac{1}{2}$ of the total weight of the coal must be burned in the combustion chamber, we find nothing but low furnace efficiency resulting from the use of such a furnace, and we find the progressive manufacturers of this type of boiler suggesting a different type of furnace to their customers to meet this changed fuel condition.

8 With the use of the coal last described, running high in volatile matter, we find in the simplest form of setting, adopted by the Heine type of boiler an excellent form of furnace, one which discharges the volatile gases from the coal upward against a more or less incandescent firebrick roof, which is constantly radiating heat and thus assisting in the maintenance of the high temperature necessary for the rapid combustion of the volatile gases, and be it understood that the more rapid the rate of combustion, the higher the resulting temperature will be. In this form of furnace, with fuel running high in volatile matter, or distilling off volatile matter rapidly, a greater height between the top of the fuel bed and the firebrick roof should be provided than with a fuel carrying less volatile matter, or one distilling off its volatile matter slowly.

9 Further in this design of setting we find a comparatively long run of gases from the furnace to the point where they enter the bank of comparatively cool boiler tubes, which design introduces the element of time necessary for the complete combustion of diluted combustible gases.

10 At the moment any fuel, whether solid or gaseous, completes its combustion, the resulting gases should be brought without delay into contact with the surfaces they are to heat, as a rapid cooling effect, due to radiation, follows cold air infiltration through settings, etc.

11 For this reason, this latter type of setting is not so well adapted for anthracite coal or coke fuel as the first described setting, owing to the fact that the combustion of such fuel, in a properly designed furnace, is almost entirely completed upon the grate bars.

12 From these well proven theories, we see that Mr. Bement has, in the form of furnace he offers, introduced the Heine type of furnace to the Babcock & Wilcox type of boiler, which will be successful, as a furnace, to the extent I have just outlined. If one were inclined to criticism, he might object to the sudden enlargement of the furnace at the inner end of the fire arch. This enlargement tends to cause a rarefication of the gases by their sudden expansion to fill the larger space found at this position.

13 Experience has taught that a condensation in the volume of gases brings their combustible portions into closer contact with the oxygen and facilitates the combination of these two essentials to combustion, which action produces the higher temperatures so essential to successful furnace operation.

14 With the chain grate stoker, which depends upon the coking method of firing, the distillation of the volatile gases is supposed to occur in the front part of the furnace (near the point of coal introduction).

15 At the rear of this grate, near the point of discharge, nothing is supposed to exist but ash, while between these two extreme positions, burning coke (resulting from the gas expelled coal) should be found.

16 Through the more or less porous coke bed and at the position of ash discharge, the greater part of the cool ash pit air passes and enters the furnace and combustion chamber.

17 One may say, this added volume to the furnace gases needs more space, but that is wrong, as this cool air tends to contract the volume of the gases by its cooling effect and the endeavor of all molecules of entering oxygen to come in contact with every molecule of combustible gas (by diffusion) becomes by far more difficult when the furnace gases are expanding.

18 At the rear of this enlarged portion of the combustion chamber, the intermixture of air and furnace gases, mentioned in paragraph 3 of Mr. Bement's paper, occurs principally through the process of diffusion, no attempt being made there, by baffling, to cause what might be termed a mechanical means of mixing of combustible gases and air.

19 The next matter to be considered is the effect of this form of setting, beyond the furnace and combustion chamber, upon the individual boiler efficiency, which efficiency is governed entirely by the difference in temperature between the gases entering the boiler proper and the temperature of these gases discharged from the boiler.

20 With bituminous coal as a fuel, tests have proved that a furnace of this form, if properly designed and manipulated, will produce high temperatures, and it then merely becomes a matter of bringing these high temperature gases into proper contact with the heat absorbing surfaces of the boiler.

21 To accomplish this end, we must see that the solid bulk of furnace gases is broken up on its passage through the boiler, so that no bulks or big masses of gas will pass from the combustion chamber to the flue outlet without giving up to the heat absorbing surfaces a very large percentage of the heat contained in their very centers.

22 This end is well accomplished by impelling these masses of gas against the staggered arrangement of the tubes found in their path of travel through the various passes of this type of boiler.

23 Of course, the slower the rate of gas travel the less the tendency towards the breaking up of these masses of gas will become.

24 Next, and most important, must we see that practically every square inch of the heat absorbing surface is equally bathed by these hot gases, by which, I mean that there must be no places where the hot gases are not constantly moving over all portions of the heat absorbing surfaces.

25 It is questionable whether such an ideal condition can be completely realized, and in attempting to realize it, we must not make sacrifices in other directions which will offset any gain we may obtain toward this desired end

26 Doubtless, many will question the desirability of throttling the flow of gases through the boiler, so as to require a forced blast under the grates in combination with an induced draft at the flue outlet, for the mere purpose of forcing the gases into a more intimate contact with the heat absorbing surfaces, as Mr. Bement's design requires.

27 A carefully conducted test would be necessary to prove the desirability of such an arrangement and the quantity of steam required to operate both fans must necessarily be charged against the boiler's performance to obtain conclusive results.

28 The advantages to be gained in the practical working of the so called "balanced draft" (referred to by Mr. Bement as being embodied in his design) are not wholly clear to me, although I do not speak from lack of practical experience in this direction and I have heard of certain desirable fuel economies following the installation of this system.

29 Of course, if we can maintain atmospheric pressure throughout the entire interior of a leaky brick boiler setting, we can prevent the infiltration of cold outside air, but with properly built and maintained boiler setting this infiltration may be reduced to a comparatively small item of loss.

30 If we judge from the figures given in section 8 of Mr. Bement's paper, his arrangement does not fulfill this condition, as we see that there is zero (or atmospheric) pressure above the fire bed, so in order to establish a positive flow of gases through the boiler, we must have less than atmospheric pressure at the flue opening, and owing to the serious obstacles (*i. e.*, the baffles) placed along this line of gas flow, this draft suction at the flue outlet must be considerable, and with such a diminution of pressure below the atmosphere, air infiltration through leaky boiler settings must occur.

31 Concerning the arrangement of tiles along the lower row of tubes, furnishing a fire-brick roof over the furnace and combustion chamber, this feature can hardly be called new. Babcock & Wilcox have used a similar arrangement for some years in their marine boiler, only, instead of firing through doors in the front of their boiler, they fired through doors placed under the rear header, the grate being placed at that end of the boiler (instead of at the front) and the firebrick furnace roof (supported by the lower tubes) extends from the rear headers, forward, leaving the opening to the tubes at the front end of the boilers.

32 A cut of this setting can be seen on p. 20 of "Marine Steam" edition of 1901, issued by the Babcock & Wilcox Co.

33 Cuts showing similar settings to that shown in Fig. 7 can be seen in the boiler catalogue of the Edgemore Iron Co., edition of 1902.

34 Almost identically the same form of brick as that shown in Fig. 3 was designed by Mr. R. K. McMurray, of this city, which has been similarly inserted and used with the water tube boilers of the Chelsea Jute Company, in Brooklyn, for a number of years.

35 One feature in Mr. Bement's design which hardly seems desirable, is the reduction in size of the boiler tubes in the bottom row from 4″ to 3½″.

36 The lower rows of tubes are always scale catchers in this type of boiler. The most scale is always found in the bottom row of tubes, a little less in the row above, and less and less impurities are found deposited in each ascending row so that in many plants, the upper rows of tubes are very seldom opened for cleaning.

37 If any change was made in the size of the lower tubes, which are the most perishable, the above facts would indicate the desirability of introducing larger (instead of smaller) tubes, which would not tend to fill up with scale so rapidly.

38 In discussing Mr. Bement's paper, Professor Breckenridge rightly states that there exists too great a division of interests between the boiler makers and the manufacturers of special furnaces, and under such conditions each unwittingly is apt to decrease the efficiency or capacity of the other's apparatus, and the owner of the steam plant is the one who suffers.

39 Having been in the boiler business for a number of years, I know that the boiler manufacturer is not seeking the combined opposition, in trade, of all the special furnace and stoker manufacturers, which would certainly follow should he go into competition with them by pushing the sale of some special furnace or stoker made by him, and further; as no one form of special furnace or stoker is equally

adapted to the use of all kinds of fuel, it is better to allow an independent selection of furnaces and their appliances, which will make it possible to select, from the large number now on the market, the one which is best adapted to the existing conditions.

40 As the generation of all the heat necessary for the operation of the boiler (and all the rest of the steam plant) occurs in the furnace, it becomes most important to see that the design of the furnace is such as will produce an ample quantity of heat, in an economical manner, from the fuel available.

41 Placing over a furnace a boiler having a heat absorbing capacity less than the heat producing capacity of the furnace would only lead to an unnecessary waste of heat, while placing over the furnace a boiler of much greater heat absorbing capacity than the heat producing capacity of the furnace, would not only reduce the possible capacity of the boiler, but the money paid for the excess of boiler heating surface would simply be wasted.

42 As the successful operation of the entire steam plant depends primarily upon the proper operation of the furnace, the furnace should be the most important consideration in steam plant design, and in my practice I have always made it so.

43 After designing the furnace best adapted to the existing fuel conditions, and making provision in it for the reception of a certain variety of grate bars, stationary or mechanical, I next fit a boiler to it, and this practice has led to the highest possible results in fuel economy and steam production.

44 Viewed from this standpoint, in accordance with Professor Breckenridge's suggestion, the special furnace and stoker manufacturers should become boiler manufacturers and turn out the complete steam generating equipment.

45 The possibility of such a departure from the present business arrangement is too impossible to need further argument.

46 There is but one solution to this unfortunate condition, and that is for the steam plant owner to employ a competent consulting engineer who is an expert in both furnace construction and steam generating apparatus and this engineer can then take charge of the entire design and produce a combined furnace and boiler equipment which will give the most satisfactory results.

47 Professor Breckenridge also refers to the 460 trials of various coals under steam boilers at the government fuel testing plant in St. Louis. I also have spent considerable time in tabulating and reviewing the results of these tests as presented in the report issued by the Geological Survey and regret to say that they have proved to be a

great disappointment to me, and, in certain ways I have found them incorrect and misleading.

48 In the first place, all of the different varieties of coal have been burned in one single form of furnace and with a very small range of difference in draft pressures. The general poor results obtained in the flue gas analyses shows in most cases that the fuel has not been burned properly, and under such conditions its true value is not to be found in the tabulated results.

49 The method of sampling used is either incorrect, or else careless work has been done. This is shown in many cases where the percentage of ash or refuse found by analysis is more than the amount obtained when the same fuel is burned in the boiler furnace. Judging from such results, one would say that they had been burning incombustible matter under the boilers. There is not sufficient draft pressure used in these tests to carry any material amount of solid matter from the fire bed over into the rear connections of the boiler, so there is no such explanation available to account for such remarkable results.

50 Most of the heat balances given are not correct as I have found that they do not check up.

51 I certainly hope that greater care will be exercised in the future at this station, as there is little reason why they should not do accurate and valuable work there and furnish reliable information which is sadly lacking at the present time.

MR. WILLIAM H. BRYAN The features of this design on which emphasis is laid are the tiled roof of furnace, and the increased number and reduced area of the gas passages among the tubes. There is little or no novelty in either of these. The tiled roof has been used successfully by builders of water tube boilers for years. Designs which leave the lower half of the tube exposed, while covering the upper half, are quite antiquated. A construction of this kind is described as far back as February, 1886, in a paper in Volume 14 of the Proceedings of the American Institute of Mining Engineers. I have in my possession a drawing bearing date of August, 1897, showing a tile for covering the tubes on the lower side. There is also an English patent, granted to Jonath Gresty in 1889, covering a similar tile. The advantages of this method have long been known, particularly with long flame fuels, such as the bituminous coals of the West, which run high in volatile matter. Whether it is of equal advantage with such short flame coals as anthracite and semi-bituminous, is not clear.

2 As to the proposed plan of baffling, the files and records of the

drafting offices of many boiler builders, and also the patent office, will show innumerable designs of this kind, very few of which, however, have met with any general adoption. The fact that such an arrangement necessitates increased draft is admitted by the author, who suggests a combination of forced and induced draft. As this is not available in the average plant, and as ordinary drafts would be insufficient, the range of usefulness of the device seems limited. Incidentally, additional complications are introduced, such as a greater number of cleaning doors, and the necessity of cleaning from the side, which is not always easily arranged for. These bafflers are exposed to high tempertatures, are quite inaccessible, and the maintenance in reasonably tight condition of the small number usually employed, is difficult. The introduction of two different sizes of tubes in the same boiler will not be looked upon generally with favor. The omission of two rows of tubes increases the space required.

3 Such an arrangement will, furthermore, cut down the capacity of the boiler, not only for regular work at rating, but particularly for overloads. Ability to carry rated load easily, continuously, and economically, and also to develop one-third to one-half above rating in emergencies, is essential in good boiler design.

4 The author dwells upon the value of the chain grate in insuring uniformity of feed of coal. This, of course, is important, but many plants are subject to wide fluctuations of load, and any apparatus to be entirely successful must so feed the fuel as to meet this condition with efficiency and with reasonable smokelessness. Admitting its many good qualities and its usual excellent performance, the claim that the chain grate—even with tiled roof—is "smoke-proof," is sufficiently novel having, so far as known, never before been made.

5 The suggestion of a combined forced and induced draft plant, has of course some merit, although it is not new. It makes it possible to secure atmospheric pressure in the fire box, thus maintaining balanced conditions and preventing leakage of cold air inward, and heated gases outward. Whether this advantage justifies the increased complication of apparatus, first cost, space occupied, and the close adjustment and manipulation necessary to obtain satisfactory results, is doubtful. Even when such a balance is maintained there must be some degree of draft vacuum in the later passages, at which points there would still be a tendency to leakage inward. A better suggestion would seem to be that of an air tight envelope enclosing all the brick work. This, with practically air tight openings, would reduce the possibility of discharges which the author fears.

6 It may reasonably be supposed that boiler builders of wide experience, who have spent thousands of dollars in experimental research, have adopted arrangements of tile which best meet average conditions of service. Naturally they hesitate to change these standard designs. On the other hand, they are usually willing to modify those designs to meet special conditions of draft, fuel, capacity, or space available.

MR. JAY M. WHITHAM The valuable paper by Mr. Bement contains two points which I wish to specially note. In paragraph 6 (p. 248), he describes a system of "Balanced Draft." In paragraph 9 (p. 250), he states "So far as the author is aware, there are no features of the above apparatus which are patented." In order that the Society may not be misinformed, I desire to call attention to Patents 817, 438, 349 and 826, which were issued to one Embury McLean. Apparatuses installed under these patents, and designated as forming a "Balanced Draft," have been installed in many places, and I have conducted tests thereon. A very brief summary of these tests is as follows:

2 In one plant containing three 60″ x 18″ horizontal tubular boilers, each with forty-six 4″ tubes, there was developed with balanced draft an excess capacity of 25 per cent over that obtaining with natural draft, the same grade of semi-bituminous coal being used on each test and the same economy in its use resulting.

3 In another plant having Berry boilers, when using semi-bituminous coal at $3.30 a ton with natural draft, as compared with rice coal at $2.25 a ton with balanced draft, and as compared with buckwheat coal at $2.75 a ton with balanced draft, the capacity developed being the same in each instance and in excess of rating, the use of rice coal showed a commercial saving of 16 per cent and buckwheat 8.6 per cent.

4 In another plant containing six 104 horse power Babcock & Wilcox boilers, semi-bituminous coal at $2.75 a ton, burned with natural draft, was compared with rice coal costing $1.75 a ton, burned with balanced draft. The commercial saving in favor of the use of the balanced draft and cheaper fuel was 29.7 per cent, the capacity developed being substantially the same.

5 In another test on a battery of two 60″ x 15″ horizontal tubular boilers, equipped with Hawley furnaces and using semi-bituminous coal, at $3.30 a ton, with natural draft, as compared with rice coal at $2.35 a ton burned with balanced draft under two boilers of identical size and in the same plant and equipped with common grates, there

was a commercial saving of 9.48 per cent, the rice coal developing as much capacity as did the soft coal.

6 In a plant consisting of two 250 horse power Keeler water tube boilers, and using soft coal at $2.74 a ton, with natural draft, as compared with rice coal at $1.85 a ton with balanced draft, there was a commerical saving by the use of the balanced draft of 26.14 per cent, the capacity being the same in each instance.

7 In a plant consisting of Babcock & Wilcox boilers, burning buckwheat coal at $2.90 a ton under natural draft, as compared with rice coal at $2.32 a ton with balanced draft, the capacity being the same on each test, there was a commercial saving of 25.75 per cent in favor of the cheaper fuel.

8 In a plant consisting of horizontal tubular boilers, using soft coal at $2.75 a ton, with natural draft, as compared with buckwheat coal at $2.25 a ton with balanced draft, and also as compared with rice coal at $1.75 a ton with the balanced draft, the capacity being substantially the same on each test, the commercial saving was 13 per cent by the use of the buckwheat coal, and 29.7 per cent by the use of rice coal.

9 In a plant having two 203 horse power Babcock & Wilcox boilers, using semi-bituminous coal, at $3.05 a ton, with Hawley furnaces, as compared with rice coal at $2.25 a ton with balanced draft, the capacity being greater with the rice coal than obtained with the soft coal, the commercial saving was 11.4 per cent in favor of the balanced draft.

10 Mr. Bement has solved the problem as to what constitutes the merits obtaining with a balanced draft in a furnace. This he explains in paragraph 6 of his valuable article when stating that the combustion is effected with a smaller air supply. In other words, the air used for dilution is a very small quantity, and by the use of this system of draft but little more than the theoretical amount is employed.

STEAM PLANT OF THE WHITE MOTOR CAR

By Prof. R. C. Carpenter, Published in November Proceedings

Mr. Warren S. Johnson Professor Carpenter has read a very interesting paper, containing much information. In paragraph 7, he says that the plant used is an example of what may be accomplished on a small scale in the use of high pressure and a high degree of superheat in a steam engine, and is consequently of interest to the mechanical engineer irrespective of its special application to the propulsion

of motor vehicles. Professor Carpenter's paper gives a more or less detailed description of the White power plant, the same being accompanied by illustrations. The paper, however, indicates plainly that there was no test of the White power plant as he says, but simply a theoretical test of the generator and engine.

2 It is hard to say why a description of the White power system, together with cuts, should be introduced in the paper, since the experiments were entirely on the efficiency of the boiler and of the engine, but entirely without the automatic regulation which is necessarily required to warrant calling it a system or a steam plant, as distinctive from other steam plants. The information as to the system, together with illustrations, are found in the literature of the manufacturing company.

3 Professor Carpenter's experiments consisted entirely of determining by experiments the value of superheated high pressure steam in small units, irrespective of the other appliances that are necessary to constitute a plant or system. It shows that what is true of the generator and the engine, as shown in these determinations, would be equally true of others, unless the White generator and engine have some special features that give it great efficiency over and above all others. If they have, it is very interesting and profitable for members of the Society to know that fact. If, however, these features are not pronounced it appears to me that this fact should have been more clearly brought out in the paper.

4 The statement is made that the engine has no special features of merit, excepting its good workmanship. The generator or boiler has no special features that would give it greater efficiency than other single tube water tube generators. The special feature in the generator consists of bringing the terminal of each horizontally disposed coil to the top and again descending to the next succeeding lower coil, this provision being used for the purpose of preventing the water which is forced in at the top from descending to the bottom, excepting through some exterior force. This provision has been used in previous boilers, and it will readily be seen that if any form of boiler of this character is sealed at the top—by a pump or otherwise—the water cannot descend, owing to the barometrical pressure, unless the coils are so disposed as to lie practically horizontally, in which case the steam might creep up and the water might run down.

5 The evaporative value of the generator, which was found to be 14.3 to 14.9 pounds of water to one pound of gasolene, is not remarkable when compared with the evaporative value of coal in ordinary fire tube boilers under forced draft, when the difference in the num-

ber of units in a pound of coal and a pound of gasolene is considered. If there is anything remarkable about it, it is that it has as great evaporative value as larger boilers have by the use of coal. The economy ought really to be greater, from the fact that the temperature of the flue gases was altogether too high. A single tube water tube boiler, in which the cold water is forced in at the top, has a great advantage in the way of abstracting valuable heat from the flue gases. It would seem, from the high temperature of the flue gases in this case, that there were not a sufficient number of horizontally disposed coils. The data given show that during the present season the cross section of the pipe or tube in the boiler has been raised seven-ninths of its former value. This greatly reduces the comparative friction and, therefore, indicates the use of a greater number of coils. I think that the restriction in the number of coils is one of convenience and to save space rather than to secure efficiency. During 1905, I made some tests on the evaporating value of a single tube water tube boiler, with differently arranged coils, and found that fifteen pounds of water were evaporated with one pound of fuel. This, you see, differs only one-tenth of a pound, as compared with the best results shown by Professor Carpenter, and indicates that the special features of the White generator cut no figure in the results. In either case the fire surface of the single tube water tube boiler is not as great as that of the ordinary automobile fire tube boiler, in which at least equally good results could have been obtained. Since there is nothing specially advantageous in the generator nor in the engine, the economy shown must necessarily be attributed to the high pressure and the superheated steam. Both of these elements have been found to be extremely economical in much larger units, and many determinations have been previously made as to their economical valuation. If the intention of the paper was to indicate these high economies in automobile use, they certainly are misleading. While the relative economy of high pressure with superheat over low pressure with saturated steam would be as great in automobile use, the economy shown—both in the evaporation and pounds of water per horse power per hour—in practice would come nowhere near the results shown in this test.

6 In the first place, a compound engine does not show economy over a simple engine, excepting when it is run under a constant load. Even in locomotive use, on lines having grades, the compound engine shows no economy, as proved by the elaborate tests made by the Chicago, Milwaukee, & St. Paul Railway. If this be the case, what can be said when a compound engine is used in the very exacting

work of automobile practice? The continual variations in the load continually change the output and the relations of the fuel to the evaporation. The repeated and often extinction of the fire, in order to secure unvarying temperature and pressure, will greatly reduce the economy in the use of fuel, and the high evaporation and small quantity of water used per horse power per hour will not be found.

7 It is regrettable that the test was not made with the apparatus as a whole, in what might be called a particular system, with all the varying conditions of load that develop in practice, so that the members of the Society could have gotten a more correct idea of the actual results. As the matter has been presented, it seems to me—as indicated in the beginning of my discussion—that the title is not really suggestive of what might be expected of the paper, and is quite liable to give a false impression as to the particular merits of the generator and engine.

MACHINE SCREW REPORT

PUBLISHED IN OCTOBER PROCEEDINGS

MR. D. A. WALLACE The following comments on the report of the Committee on Machine Screw Standards are based on an experience in the manufacture of 400,000 taps and the use of ninety million commercial machine screws per year.

2 The Western Electric Company, some eight years ago, decided to make its own taps and the question arose as to what size to make them so that commercial screws bought from the several screw manufacturers could be used indiscriminately. A prominent maker of small tools was appealed to, who evolved a set of reference gages which were understood to represent a mean of all the varieties of screw sizes then on the market. This set of standards has been used with varying success since that time, but the mean size of a given diameter of commercial screw has evidently changed several times in eight years, for it is no longer possible to get screws to match these gages reasonably well without having the screws made to order.

3 Previous to the use of the screw thread micrometer, these gages were held sacred but accurate measurement has brought to light irregularities as to shape of thread which would make any good mechanic shudder. If, therefore, it was not possible for an expert gage maker to produce gages which have the same depth and shape of thread on the various sizes having the same number of threads per inch, it may be possible to excuse some of the evil the screw makers have done.

4 The variety of sizes on the market has apparently been more the result of the various conceptions of the proper shape of thread and fit of the screw than an actual difference in standards, and if the extent of these variations is not too great, it would be better to strike a compromise standard instead of establishing a new one. The screws now in use provide a convenient variety of diameters and pitches and all that is lacking is a recognized standard of limits for manufacturing taps and screws and the amount that shall be allowed between taps and screws to take care of wear and insure a commercial fit.

5 The Western Electric Company has for its own use already traversed the same ground that the Committee has covered in establishing limits for both screws and taps and the results are somewhat similar, but we find that the allowances recommended by the Committee may generally be increased without detriment and we believe that screw and tap makers would find the limits recommended too irksome. The upper dimensions for the pitch diameters on taps, for instance, should be raised, and the upper dimension on sizes above .125 should be considerably increased. The minimum pitch diameter for screws up to the .125″ size represents good practice but above that size the minimum diameter may be lowered to advantage.

6 We have found it impracticable to attempt to make taps and dies with the roots of the threads flatted, since on the coarsest pitch on the list recommended, the flat is less than .008″; we therefore make taps as sharp as the tools will make them at the roots, and the dies are also made to cut the screw sharp at the root. In the case of tapped holes the size of the tap drill gives the necessary amount of flat, and in the case of screws, the die is made to form the flat at the top of the thread. It seems a useless refinement to expect tap makers to follow the flatting given by the formula recommended. The results of these formulæ would have to be trimmed somewhat for everyday use, by dropping, at least, the fifth decimal. The chief criticism of the committee's work is that it has adhered too strictly to the formulæ, which probably are of faulty construction to start with. If any trimming of the results of the formulæ is to be done, it should be done now and not left to the varying ideas of all who are to use them.

7 As has already been pointed out, the great variety of widths for slots would not be tolerable and the list should be modified to make possible the use of the present stock sizes of slotting cutters. The depths of the slots recommended for flat-head screws are in every case less than the width, which gives a slot that is too shallow. A slot halfway through the head would be more nearly right and would not materially weaken the head.

8 The diameters for flat-head screws given in Table 14 seem to be about right for sizes below .140 diameter, but are a little too large for the larger sizes.

9 The 80 degree angle seems to be nearer the practice of most screw manufacturers at present than 82 degrees, although we find screws varying from 76 to 82 degrees and there seems to be no good reason for making the angle 82 degrees.

10 In Table 11 the sizes of round-heads for screws below .190 appear too large in diameter and too low.

11 The plan of having only one pitch for each diameter is probably correct if the screws are to be used in tapped holes in steel, but would not suit the requirements of general manufacturing as it is often necessary to use machine screws in such materials as hard rubber, fiber, Norway iron, etc., which demand coarser pitches than those in the list. Other pitches as well as other diameters would be required, but of course could be considered special.

12 Another difficulty in the use of machine screws, particularly those with rolled threads, has been the variation in the lengths. It might be well, while the screw manufacturers are in a willing mood, to establish limits for this dimension as well as the diameters.

MR. OBERLIN SMITH. While desiring to give the highest credit to the Committee who have labored so faithfully in arranging a new standard for machine screws, and much of whose work seems to me entirely satisfactory, I am yet constrained to point out certain inconsistencies which should be remedied before a final standard is recommended by this Society. Referring to the report:

2 In the 3d and 4th paragraphs: The standard diameters of $\frac{5}{16}''$ and $\frac{7}{16}''$ should not be excluded, and the substitute numbers should not be adopted, as they would be too nearly like the standard screw sizes already existing in the U. S. system. We do not want to duplicate diameters—or nearly so. In 8th and 9th paragraphs: The mixing up of the truncatings of $\frac{1}{16}$ and $\frac{1}{8}$ of the pitch is an unnecessary refinement which is all right for feed screws in lathes, etc., where the nut is made to close together to take up wear in the thread; but it is of no particular advantage in ordinary screws and nuts, where the threads may just as well touch on the edges as anywhere else. As a matter of fact, the truncations soon become worn and rounding, resembling the Whitworth thread. There is no danger but what the longitudinal stress on the screw will practically come upon the conical faces of the thread. This different amount of flattening makes confusion in measurements, and is practically useless in the case of articles as small

as machine screws. It is a complexity which deals with measurements hardly discernible and yet adds trouble in tool making and screw making. Moreover, the screws are positively weaker by having the bottom of the grooves cut deeper, thereby reducing the minimum diameter and, consequently, the cross section which resists the working stresses.

3 In 12th paragraph: The diameters given in Table 1 do not run in a systematic progressive series, so that if plotted as ordinates the resulting curve would be approximately smooth. [It would, on the contrary, be of a jagged shape with unnecessary steps. It is very desirable that the respective diameters of these screws should be uniform with some established wire gage, which engineers and manufacturers are habitually using. Referring to my book, "Press Working of Metals," pp. 103 and 105, it will be seen that there are twenty-five distinct wire or sheet gages in common use, and that nearly all of them are extremely illogical and very confusing. On p. 112, etc., is described the new decimal gage, my patent for which was assigned to this Society for the public benefit, and considerable numbers of which have been manufactured under the Society's license. The railway master mechanics' and car builders' societies have adopted this gage, which is absolutely simple and flexible, being arranged to contain any desired quantity of notches of any suitable size to adapt it for different industries. The distinguishing feature about it is the same as that proposed by Whitworth, with the number marked at each notch, representing the number of thousandths-of-an-inch which the notch measures. The notches referred to, as adopted by the above named associations are, in inches, as follows:

.002—.004—.006—.008—.010—.012—.014—
.016—.018—.020—.022—.025—028—.032—.036—
.040—.045—.050—.055—060—.065—.070—
.075—.080—.085—.090—.095—.100—.110—
.125—.135—.150—.165—.180—.200—.220—
.240—.250.

4 Of course in a gage of this kind every possible number within the desired limits need not be used, but in selecting them due regard should be had to obtaining a proper progression, with increments in good proportion. It will be noticed that in expressing the differences between the successive numbers in the above series, forming the increments referred to, the number 2 is used ten times, then 3 twice, then 4 thrice, then 5 twelve times, then 10, then 15, then 10

again, then 15 three times, then 20 and then 10 as a finish. This last and serious break in the progression is doubtless allowed so as to end up at an even quarter-inch, but it is obvious that the numbers would plot a rather bad curve, especially toward the end, and some of them are needlessly close together.

5 By referring to p. 117 of the above named book, a diagram will be seen which gives a logical series of numbers for a wire gage, with the resulting curve plotted. This is not perfectly smooth, but near enough for all practical purposes, the slight irregularities being due to using only three decimal places rather than more. The writer at the time urged that these numbers be used for the "decimal" gages that were made. They are no more in quantity and they certainly form a logical series. It avoids the objectionable and unnecessary millionths of an inch used in the B. & S. gage, which though correct and having a smooth series, is *retrogressive*, as it has the largest numbers representing the smallest notches, and therefore is illogical. It should be noted that in the gage shown on p. 113 of the book, the notches progress as in the Birmingham wire gage known as B. W. G. Such an arrangement shows the flexibility of the system, but it is not recommended for an ideal working tool.

6 In the 44th paragraph: The measuring of threads by the gage shown in Fig. 8 would seem objectionable, because centers of the spherical jaws do not lie in a plane normal to the axis of the screw, and therefore do not determine its true diameter. Furthermore, these jaws, having but a point of contact with each thread, would soon wear with flatted spots by continual use. It would seem that a gage with forked jaws at one side, to enter two adjacent threads, and one jaw at the opposite side, coming half between them, would keep the plane of the gage at right angles to the screw, giving the true diameter. The jaws could be of a V-shaped form, the forked ones adjustable to different distances apart, and all of them swiveled to suit the angle of the thread. This is only a hint at a correct principle of construction, without the details being worked out.

7 In the 46th paragraph: Referring to Table 11, the shape of the heads should be re-formed if possible, so as to show in axial section one circular arc, rather than three different connected ones. If this should prove impracticable, then the arc should be elliptical, preferably with the bottom diameter of head representing the long axis.

8 The diameter and thickness of head, as well as the width and depth of slot, should all have a simpler relation to the diameter of the body A, preferably expressed in one place of decimals instead of two or three. There seems no possible reason for such a remarkable

figure as .703 of a screw diameter for the thickness of its head. The product of A multiplied by this constant would sometimes be expressed in millionths of an inch—a refinement rather too much refined.

9 Just how all the wonderful fractions embodied in the tables have been obtained does not appear. It is probable, however, that too much attention has been paid to following old standards. Of course it is somewhat difficult to break away from these, but as they are now so varied in character in the products of different manufacturers, this would seem a good time, when planning a scheme which may last for a century or so, to make changes enough to get convenient measurements and a systematic progressive series for each dimension.

10 Concerning Tables 12 and 13, the same remarks apply as to almost all the measurements. The word "oval," used for a spherically convex head, is certainly a misnomer and should not be used in this sense, particularly in our Transactions.

11 Regarding Table 14, the bevel of the head should be stated in angular measurement, and certainly should be 80 degrees rather than 82 degrees, providing this old angle must be approximately retained. A much more convenient angle, which has long been used successfully by the writer both for drafting room and shop, is 90 degrees. If it is argued that this angle makes the head too weak under the slot or too fragile at the outer edge, then make the whole head a trifle deeper and flatten off the outer edge a little into cylindrical form, making it exactly twice the diameter of the body. This slight flattening off always occurs in practice and might just as well appear in the design of the screw, so it could be known how much the flattening should be, just as is the case with the points of screw threads. The slot should of course be the same as in the other machine screws, in regard to width, and of some even proportion thereof in depth. Such a head would be easier to work into drawings, and to prepare tools for, and would not attempt to have a sharp ragged edge accidentally "dubbed off" somewhat. Proportions of this kind would be convenient for all countersunk screws of sizes far above those of machine screws.

12 In general, the excellent work done by the committee should be so far modified as to embody the primal idea of simplicity which has been hinted at in the foregoing criticisms.

13 All series should be plotted to detect unsystematic progressions, by seeing that the resulting curves are reasonably smooth, with the general idea of making each increment over a given size somewhere near a constant percentage of that size. All this need not be done accurately, as little variations from the theoretical size may be

made to suit practical conditions, and to express values in fewer places of decimals. It would seem as if three places would be ample, as a maximum, for work of this kind.

14 Another important object to be sought is a definite correlation between machine screw sizes and U. S. bolt sizes. These latter in the main are good, but might be a little modified on the smaller sizes, say below half-inch, in the way of using finer threads and meeting the machine screws in an unbroken series.

15 As a matter of fact, the statement sometimes made that all the U. S. threads are too coarse is not true—for who of us has not been more bothered with stripped threads than broken bolts, especially after the nuts have worn loose, or in cases where the makers have carelessly made them loose.

16 This whole matter has recently become more complicated by the adoption of a separate set of threads, heads, and nuts by the automobile manufacturers. With their fine pitches they will probably find more trouble from stripped threads than they expect, unless indeed they are very particular to make nuts of considerable length and of excellent fit. It is much to be regretted that their committee did not work in connection with our committee and arrange as much harmony as possible between their set of fine threads and our set of coarser ones. Some of their sizes run in needlessly unsystematic progressions, apparently showing that little care was taken to get the series regular.

17 In view of all that has passed, it seems a pity that our Machine Screw Committee was not a *screw thread* committee in general. They could then have taken up the question of ordinary bolts and brought the whole series into harmony, from the smallest machine screws to the largest bolts that are now made, or are likely to be made.

18 The watch screw question does not seem to have been considered by our Committee, as the smallest diameter treated is a little less than $\frac{1}{16}''$. The threads, heads, and other dimensions of watch screws as well as machine screws should be considered and that on upward to big sizes, as regular fillister head machine screws are sometimes made as large as 4″ in diameter.